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INSECTS AND OTHER PESTS ATTACKING AGRICULTURAL CROPS

E. O. ESSIG and W. M. HOSKINS

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B. H. Crocheron, Director, California Agricultural Extension Service.

THE COLLEGE OF AGRICULTURE
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CONTENTS

Some of the materials mentioned in this circular may become scarce or unavailable for civilian use because of the war. Where two or more chemicals are effective in the prevention, control, or treatment of an insect, all have been mentioned. If the reader finds that none of these are available now, he will naturally do the best he can with any substitutes obtainable. In certain cases concentrations of insecticides are recommended higher than those permitted under present government regulations. In such cases careful applications with the concentrations allowed will probably give satisfactory results. Great caution should, however, be exercised in the use of substitutes, particularly those untested for the proposed service. When in doubt about the advisability of using substitutes, readers should consult the farm advisors in their respective counties or the Agricultural Extension Service, University of California, Berkeley 4, California.

INSECTS AND OTHER PESTS ATTACKING AGRICULTURAL CROPS[1]

E. O. ESSIG[2] AND W. M. HOSKINS[3, 4]

INSECT PESTS BY CROPS

ALFALFA

Clover or Almond Mite, *Bryobia praetiosa* Koch.—This mite may appear in great numbers on alfalfa in the semiarid regions. Dusting with fine grades of dusting sulfur when temperatures are above 90° F is recommended only in cases of severe infestations. For description, see under "Almond" (p. 7).

Grasshoppers.—See page 142.

Flower or Grass Thrips.—See under "Peach" (p. 95).

Pea Aphid, *Macrosiphum onobrachis* (B. d. F.) (*M. pisi* Kalt.).—A large green aphid is often destructive to alfalfa in many parts of southern California. Spraying and dusting as suggested for this insect under "Pea" (p. 93) are usually impractical in alfalfa fields, but may be resorted to under certain conditions. Thorough irrigation after cutting; burning the stubble with an oil burner, as used for the destruction of foxtail and weeds; the application of 4 per cent nicotine dust or granular cyanide under certain conditions; and the use of a chain drag to kill the aphids on the small plants may prove helpful in combatting the pest. (See fig. 1.)

Western Plant Bug, or Cotton Dauber, *Lygus hesperus* Knight, **Alfalfa Plant Bug,** *L. elisus* V. D., **and Aster Plant Bug,** *L. oblineatus* (Say).—The plant bugs attacking alfalfa are mahogany-colored, yellow, or brownish insects about ¼ inch long, with a small triangle between the bases of wings, the tips of the leathery portions of the front wings deflected, and the overlapping membranes with veins forming two small loops. Hibernation occurs in the adult stage. Eggs are inserted into stems, buds, and flowers in the spring, and four or more generations follow at monthly intervals. Damage to the hay crop consists in stunted growth and is seldom acute enough to warrant control measures other than the general elimination of all eggs and nymphs by a unified cutting program. Greatest injury occurs after cutting has ceased in

[1] This circular replaces those portions of Circular 265, *Plant Disease and Pest Control*, that deal particularly with insects, mites, and related animals, attacking agricultural crops in California. A number of Experiment Station publications treating single insects or groups of insect pests are available and may be selected from a list of publications obtainable from the College of Agriculture, Berkeley, California, upon request. This list includes also a series of circulars on diseases and one on rodents, which replace other portions of Circular 265.

[2] Professor of Entomology and Entomologist in the Experiment Station.

[3] Professor of Entomology and Entomologist in the Experiment Station.

[4] Other members of the staff who have contributed to the revision of this circular are H. J. Quayle, G. F. MacLeod, R. H. Smith, J. E. Eckert, S. F. Bailey, A. D. Borden, L. M. Smith, A. E. Michelbacher, G. L. Smith, E. G. Linsley, W. H. Lange, E. M. Stafford, and R. L. Usinger.

seed-growing areas. Here the bugs build up to enormous numbers and cause blasted buds, falling of flowers, and failure to set seed. For control see "Western Plant Bug" under "Cotton" (p. 58).[5]

Three-cornered Alfalfa Hopper, *Stictocephala festina* (Say).—This stout green leafhopper is about ¼ inch long, with a sharp, backwardly projecting plate above. Adults hibernate during the winter and deposit their eggs in slits in stems during the spring. Three or four generations develop at 2-month intervals. Injury is caused by sucking of plant juices and by mechanical damage such as feeding scars, stem girdles, and gall-like growths. A unified

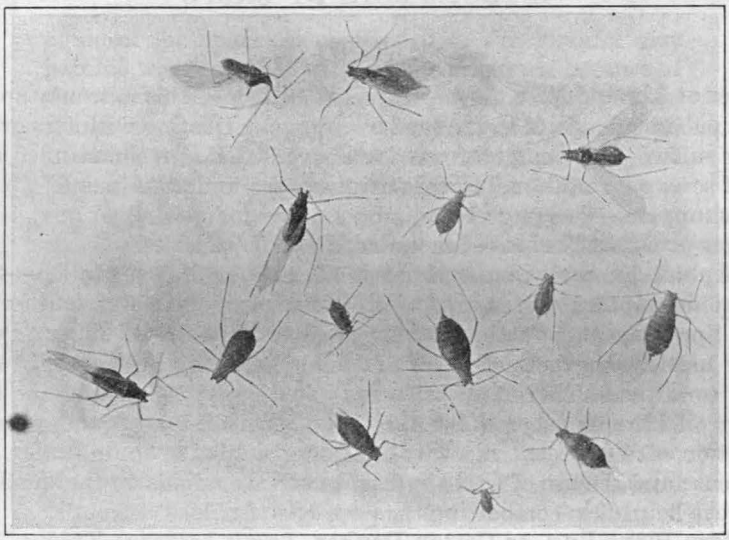


Fig. 1.—The pea aphid, *Macrosiphum onobrachis* (B. d. F.), often a serious pest of alfalfa and peas.

cutting program destroys large numbers of nymphs and prevents survival of migrating adults, and clean culture during the winter months eliminates many of the hibernating adults.

Armyworms and Cutworms.—The most important California species feeding on alfalfa, in order of their seriousness, are yellow-striped armyworm, *Prodenia praefica* Grote; beet armyworm, *Laphygma exigua* (Hbn.); alfalfa semi-looper, *Autographa californica* (Speyer); corn earworm, *Heliothis armigera* (Hbn.); and tarweed cutworm, *H. phloxiphaga* G. & R. For the type of armyworms that feed at night and hide in the debris covering the ground during the day, see page 144. The yellow-striped armyworm, which is nearly black in color with yellow stripes down the sides, spends its entire life on the plants and feeds during the day. The caterpillars are killed off in large numbers by a wilt disease, but this usually does not set in until considerable damage is done. The pest can best be controlled by cutting the alfalfa before economic damage is done. See also page 145.

[5] For further information, see: Smith, Gordon L. California cotton insects. California Agr. Exp. Sta. Bul. 660:3–10. 1942.

Alfalfa Caterpillar, *Colias eurytheme* Bdv.—The caterpillars (fig. 2) are about 1 inch long, dark green with a distinct line on each side, which is often pale yellow or white. They feed on the leaves and may entirely defoliate the plants. They also feed upon other legumes, including beans, clovers, locoweeds, melilotus, peas, vetches, and others. The yellow butterflies (fig. 3) and the less frequent white forms may be seen in great numbers hovering over alfalfa fields in the summer. There are many natural factors that tend to limit the damage done by this most serious of the alfalfa pests. In the cooler coastal regions, climate holds the pest in check; in the warmer areas, there are many parasites and a wilt disease which limit the populations. Cutting alfalfa as soon as the caterpillars are noted in the summer is advisable. Thorough and timely dusting with sulfur has given remarkably good control of this insect in the warm interior valleys.

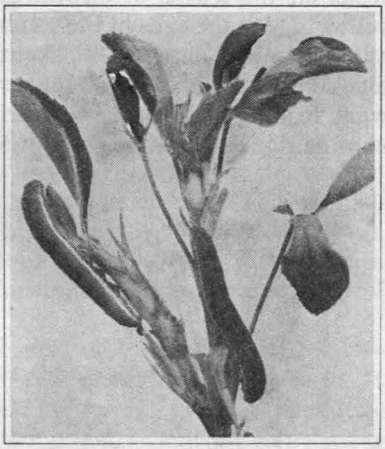


Fig. 2.—Mature caterpillars of the alfalfa butterfly, *Colias eurytheme* Bdv., and the nature of their work on alfalfa plants. (From *Hilgardia,* Vol. 15, No. 4.)

Alfalfa Weevil, *Hypera postica* (Gyll.).[6]—The adult stage of this insect

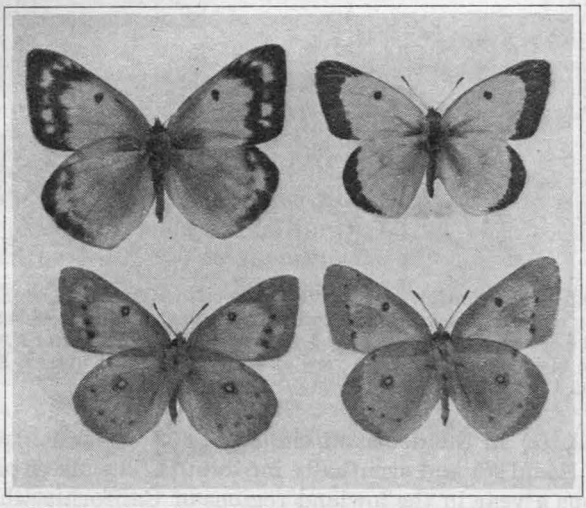


Fig. 3.—Alfalfa butterfly, *Colias eurytheme* Bdv.: left, top and bottom views of the female; right, same of male. (Three-fourths natural size.) (From *Hilgardia,* Vol. 15, No. 4.)

[6] For further information, see:

Essig, E. O., and A. E. Michelbacher. The alfalfa weevil. California Agr. Exp. Sta. Bul. 567:1–99. 1934. (This bulletin is out of print but may be consulted in many city and county libraries in California.)

Michelbacher, A. E. The present status of the alfalfa weevil in California. California Agr. Exp. Sta. Bul. 677:1–24. 1943.

(fig. 4, *G* and *H*) is a small brown weevil, or snout beetle, 3/8 inch long, which feeds on the leaves of alfalfa and related plants and lays its small, oval, yellowish-orange eggs in the stems of the plants (fig. 4, *A*). The mature larvae (fig. 4, *B* and *C*) are legless, about 1/4 inch long, and bright green, with a small black head and a white stripe down the back. Although the stems are somewhat injured, the larvae are primarily leaf feeders and when enormously abundant may defoliate the plants. When mature the larvae spin thin lacelike

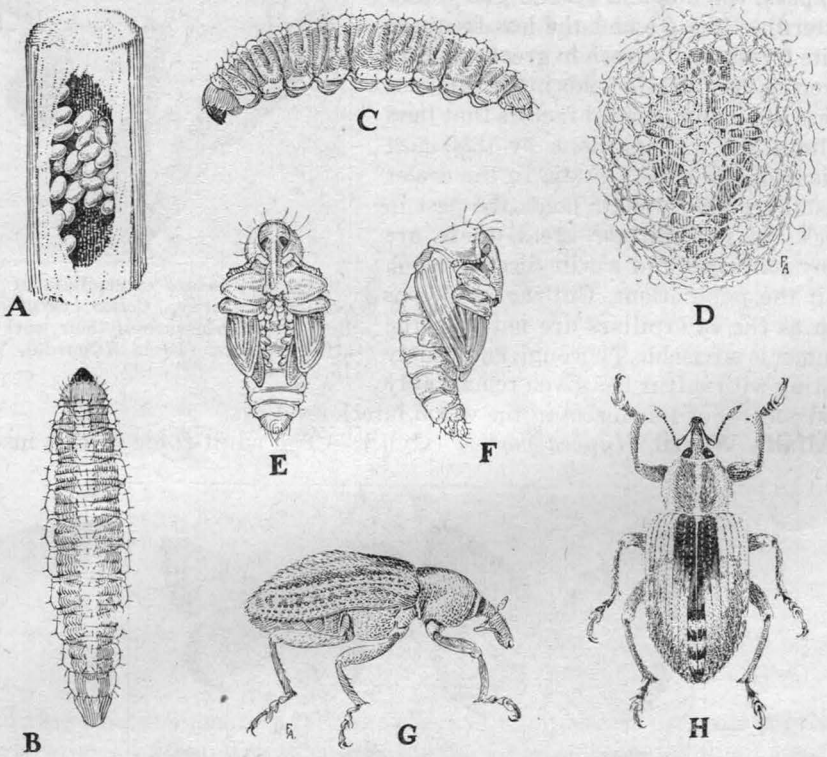


Fig. 4.—Life cycle of alfalfa weevil, *Hypera postica* (Gyll.): *A*, alfalfa stem cut open, showing a cluster of eggs; *B*, top view of larva; *C*, side view of larva; *D*, pupa within lacelike cocoon; *E*, pupa removed from cocoon, bottom view; *F*, side view of pupa; *G*, side view of adult; *H*, top view of adult. (Six times natural size.) (From *Hilgardia* Vol. 13, No. 3.)

cocoons (fig. 4, *D*) in the debris at the bases of the plants, transform into pupae (fig. 4, *E* and *F*) and eventually into adults. The insect passes through two generations a year in the lowland regions of California where it occurs. The alfalfa weevil is heavily parasitized by the larval parasite *Bathyplectes curculionis*, which is very important in checking damage by the pest in the coastal regions. In the interior valleys, climate and frequent cuttings tend to restrict the pest, and serious damage has occurred only in localized areas. Serious injury can usually be prevented by keeping the alfalfa growing vigorously and by timely cuttings. Large numbers of larvae and pupae are killed by the heat of the sun after mowing.

Repeated mowings are of great importance in keeping this insect in check in California.

Whenever sufficiently injurious, the weevil may be most cheaply controlled by dusting with a mixture of equal parts of commercial calcium arsenate and dusting sulfur, applied at the rate of 4 to 6 pounds per acre. The dust should be applied at least 10 days before cutting.

Clover Leaf Weevil, *Hypera punctata* (Fab.).—The clover leaf weevil is somewhat similar in appearance to the alfalfa weevil except that the various stages are much larger. The posterior portion of small larvae have a pinkish tinge, and when mature the pale stripe down the back is bordered with pink lines. Although widespread and similar in habits to the alfalfa weevil, it has been observed only rarely as a pest in California. This insect is discussed in Bulletin 567 (see footnote 6, p. 5).

Clover Seed Chalcid, *Bruchophagus gibbus* (Boh.) (=*funebris* How.).—The small white larva of this insect is just large enough to fill the seed. It occurs in sufficient numbers to reduce the seed crop greatly in most localities in the state. Destroying all the seed heads during winter and the straw after threshing, and planting clean seed will greatly reduce the infestation for the next year.

ALMOND

(See also "Nuts in Storage," p. 87)

Clover or Almond Mite, *Bryobia praetiosa* Koch.—The almond mite (fig. 5) is brownish or greenish with reddish legs, the front pair much longer than the other legs; the back of the body is flat. The bright-red, globular eggs are laid in great numbers on the limbs and twigs of the trees in the fall. The winter is passed in the egg stage and as adults hiding under loose bark or feeding on orchard weeds and covercrops during warm winters. Controls in order of preference are: (1) 4 per cent winter tank-mix oil spray, or 4 per cent emulsive oil (see p. 165), or 5 per cent commercial oil spray; (2) winter lime-sulfur 1–10; (3) in summer, sulfur dust; (4) in summer, dinitro (DN) dusts (see p. 160); (5) summer tank-mix oil or commercial oil spray 1½ to 2 per cent plus a good spreader; (6) in summer, lime-sulfur 1–50 plus 5 pounds of wettable sulfur per 100 gallons of water.

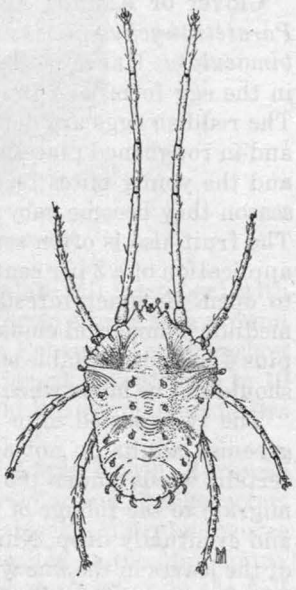


Fig. 5.—The clover or almond mite, *Bryobia praetiosa* Koch. Note the long forelegs and the plumelike body hairs. (Greatly enlarged.)

Two-spotted Mite, and the Pacific Mite.—See under "Plum and Prune" (p. 102).

San Jose Scale.—See under "Apple and Quince" (p. 11).

Red-humped Caterpillar.—See under "Plum and Prune" (p. 102).

Pacific Peach Tree Borer.—See under "Peach and Nectarine" (p. 97).

Peach Twig Borer.—See under "Peach and Nectarine" (p. 97).

APPLE AND QUINCE

General Spray Program.—

1. *Full dormant treatment* (January to February) for control of scale insects, mite eggs, and aphid eggs: use 2 gallons of dormant oil emulsion with one of the dinitro compounds per 100 gallons of spray (see "Green and Rosy Apple Aphids," p. 9).

2. *Cluster bud spray* (March to April) for control of scab, powdery mildew, or immature mites:

Liquid lime-sulfur solution	2 gallons
Wettable sulfur	4 pounds
Water	100 gallons

3. *First and second calyx sprays* (first when 50 per cent petals are off; second to begin 10 days later than the beginning of the first) for codling moth, powdery mildew, and immature mites:

Powdered standard lead arsenate	4 pounds
Wettable sulfur	4 pounds
Water	100 gallons

4. *Cover sprays* (timed by bait-trap method) for codling moth:

Powdered standard lead arsenate	3 pounds
Spreader as recommended by manufacturer	
Water	100 gallons

Clover or Almond Mite, *Bryobia praetiosa* Koch; **European Red Mite,** *Paratetranychus pilosus* (C. & F.); **and the Two-spotted Mite,** *Tetranychus bimaculatus* Harvey.—The clover mite and the European red mite overwinter in the egg form, and the adults, which are brown or red, do not form webs. The reddish eggs are deposited in great numbers on the bases of fruit spurs and in roughened places on twigs and limbs. These eggs hatch in early spring, and the young mites feed on the opening blossoms and leaves. Later in the season they become very numerous and cause the leaves to yellow and drop. The fruit also is often scarred from their attack. Control is best obtained by application of a 3 per cent dormant oil emulsion applied before the buds begin to open. Summer infestations may be controlled with 1½ per cent light-medium summer oil emulsion or by applications of 1 gallon liquid lime-sulfur plus 4 pounds wettable sulfur per 100 gallons of water. Summer applications should not be made when maximum temperatures are above 85° F.

The two-spotted mite overwinters in the ground, and the pale-yellow to greenish adults do not appear until in May or June. They usually feed on certain weeds under the trees until the weather becomes warm, when they migrate to the foliage of the fruit trees. They cause the leaves to turn brown and eventually drop. Numerous pale-yellow eggs are found on the underside of the leaves in the fine webbing formed by the adult. The infestation usually lasts 3 or 4 months and often causes complete defoliation of the tree before the mites disappear as they return to the soil. The seriousness of attack is directly associated with climatic conditions and soil moisture. No winter treatment is effective for this mite. Summer treatments are the same as given for the two mites listed above.

Woolly Apple Aphid, *Eriosoma lanigerum* (Hausm.).—This aphid (fig. 6) is easily distinguished by its reddish body completely covered with white woolly wax. During the winter months, spray with 3 gallons of dormant oil emulsion plus 3 gallons of liquid lime-sulfur solution per 100 gallons of water during the full dormant period. Band tree trunks in the early spring (March or April) with sticky banding material to prevent migration of aphids from the roots to the tops of the trees. Practice summer (July to August) spraying with a solution of 1 gallon of whale-oil soap and ¾ pint of 40 per cent nicotine sulfate per 100 gallons of water to kill aphids on limbs and fruit (blossom

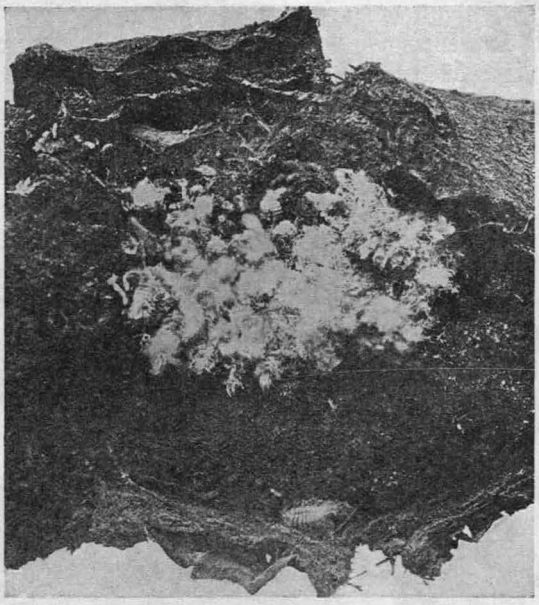


Fig. 6.—A colony of the woolly apple aphid, *Eriosoma lanigerum* (Hausm.), in a wound on a branch.

ends). To kill aphids on the roots, treat the soil in the late fall (October) with paradichlorobenzene, 2 to 3 ounces per tree (according to size of area around the tree treated); or in fall or winter (September to February) with carbon disulfide emulsion, diluted 1 part to 200 parts of water, at the rate of 5 to 10 gallons per tree. Both of these fumigants may injure or kill young trees unless used very sparingly.

Green Apple Aphid, *Aphis pomi* DeG., **and Rosy Apple Aphid,** *A. roseus* (Baker).—These aphids are easily identified by their color and the characteristic curling of the leaves caused by their method of attack. Control measures are directed at the overwintering eggs which are deposited on the fruit spurs, buds, and new-growth twigs and suckers. A thorough application in the full dormant period (January and February) of an oil and dinitro combination (see p. 160) gives excellent control. The recommended formulas are:

Dormant oil emulsion	2 gallons
Dinitro-*o*-cyclohexylphenol powder	1 pound
Water	100 gallons

or

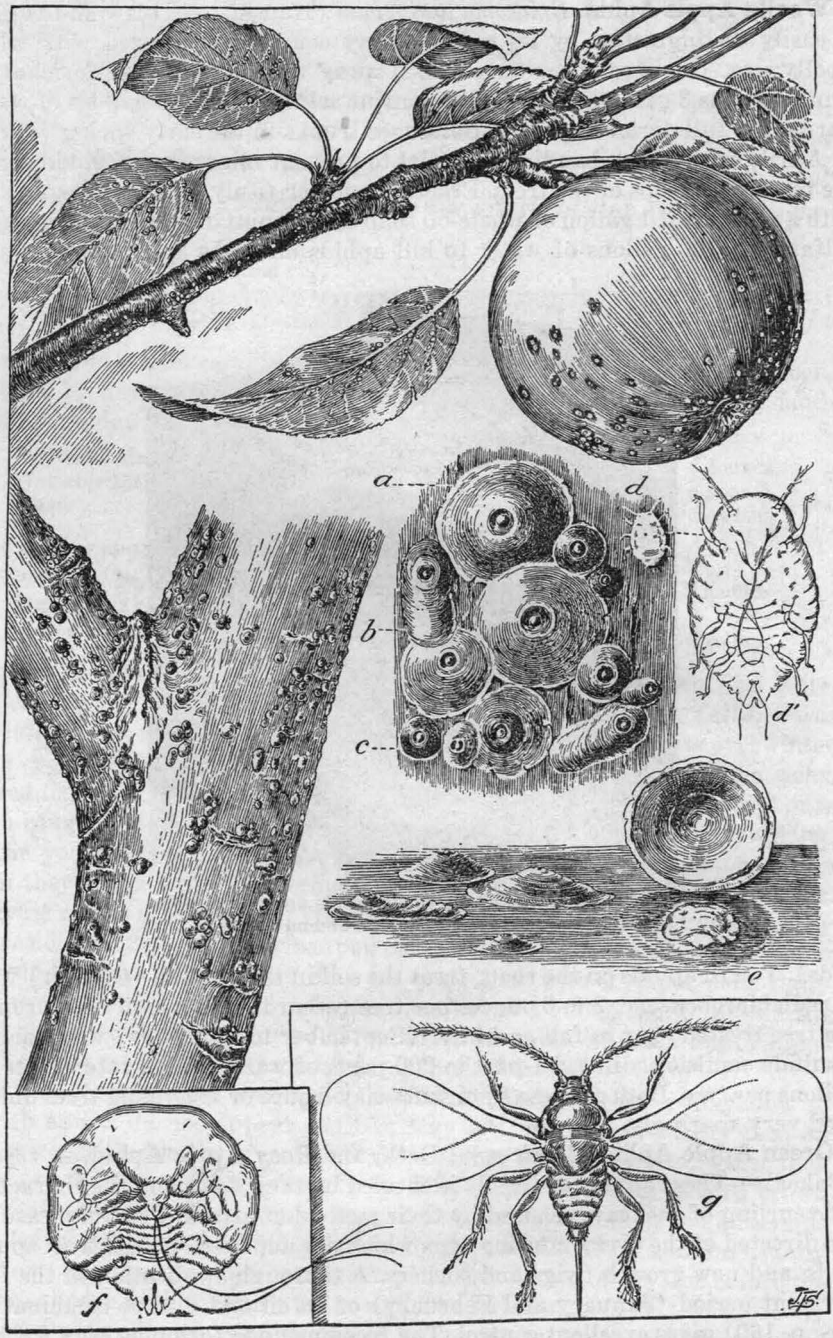


Fig. 7.—The San Jose scale, *Quadraspidiotus perniciosus* (Comst.): *a*, adult female scale; *b*, male scale; *c*, young scales; *d*, larva just hatched; *d'*, same, much enlarged; *e*, scale removed, showing body of female beneath; *f*, body of female insect, more enlarged; *g*, adult male. (After United States Department of Agriculture.)

Dormant oil emulsion	2 gallons
Sodium dinitro-*o*-cresolate liquid	1⅓ quarts
Water	100 gallons

See page 160 for discussion of the various dinitro compounds.

San Jose Scale, *Quadraspidiotus perniciosus* (Comst.) (*Aspidiotus perniciosus* Comst.); **Oystershell Scale,** *Lepidosaphes ulmi* (Linn.); **and Other Scale Insects.**—The scales of San Jose scale (fig. 7) are circular and gray; and those of oystershell scale are oyster-shaped and similar in color. They occur on all parts of the tree, the first causing a red or purplish stain on the bark and fruit. For the San Jose scale alone, spray during the dormant season with lime-sulfur 1–10. For all species use 3 per cent tank-mix oil of winter grade, or 5 per cent commercial winter oil emulsions. The lighter oil sprays are not so efficient as the heavier oil emulsions for the winter control of these insects.

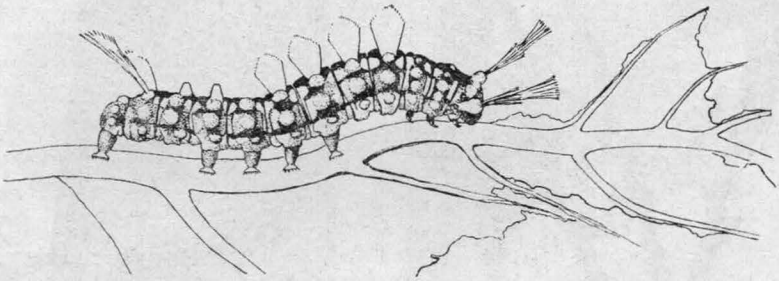


Fig. 8.—The larva, or caterpillar, of the California tussock moth, *Hemerocampa vetusta* (Bdv.).

Cankerworms.—See page 148.

Tent Caterpillars.—See page 147.

Tussock Moths: California, *Hemerocampa vetusta* (Bdv.), **and Antique,** *Notolophus antiqua* (Linn.).—The caterpillars (fig. 8) are brilliantly colored and clothed with tufts of white hair on the dorsum, and a single long black tuft at the rear and two in front, the last being responsible for the name "horn worms." The eggs appear as white, flat, felty masses on the old cocoons and on the limbs of the trees. They are deposited in late summer and fall, but do not hatch until the following spring. The female moths are wingless, but the males are normally winged.

Control is most easily accomplished by removing the egg masses during the winter months. Great numbers of the caterpillars may be jarred from the trees and their reascending prevented by applying a band of cotton, wire screen, or sticky bands around the trunks. Oil sprays applied shortly after the eggs hatch readily kill the young caterpillars. Such sprays are also of value in reducing the codling moth, skinworms, pandemis, cankerworms, bud moth, and other caterpillars. Poison sprays are of little use.

Apple Skinworm, *Tortrix franciscana* (Walsm.).—The apple skinworm somewhat resembles the fruit tree leaf roller. The caterpillars are most numerous and destructive in the fall of the year, when they feed on the skin of the

fruit at points of contact or at the stem and blossom ends. If carried on the fruit into storage, they will continue to injure the fruit unless the fruit is subjected to cold-storage temperatures or fumigated with methyl bromide, 2 pounds per 1,000 cubic feet. See "Codling Moth" under "Pear" (p. 99).

Best control has been obtained by destroying the egg masses. An early application of 2½ gallons of lime-sulfur per 100 gallons of water or 2 per cent winter oil emulsion or tank-mix oil (p. 166) applied on the trunk and main limbs will destroy the egg masses occurring before blossom time. Two or three applications of summer-type oil emulsion, 2 gallons per 100 gallons of water, on the foliage and fruit at intervals of 3 weeks after blooming will destroy later broods. Usually about three applications are sufficient.

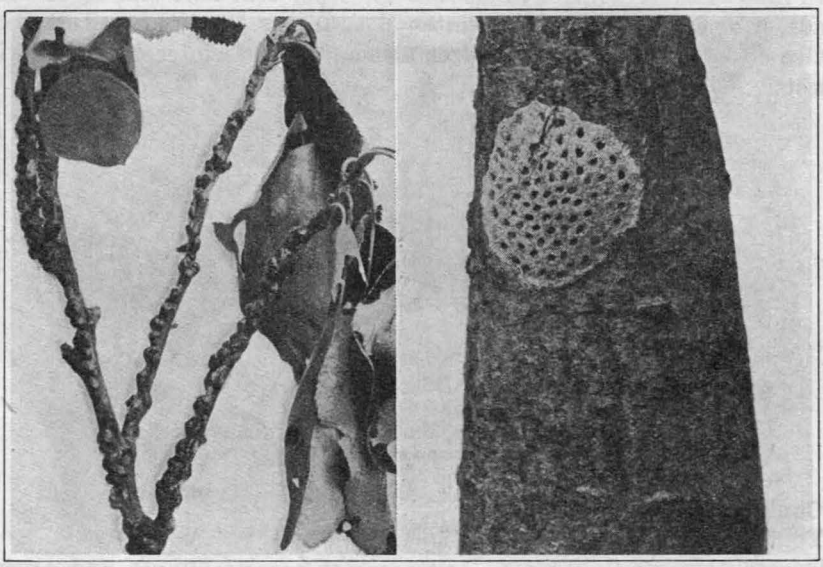


Fig. 9 Fig. 10

Fig. 9.—The brown apricot scale, *Lecanium corni* Bouché, on small twigs of apricot, mature specimens. Only very small scales survive the winter, and they occur on the new wood.

Fig. 10.—The egg mass of the fruit tree leaf roller, *Tortrix argyrospila* (Walk.), showing the exit holes where the minute caterpillars emerged in early spring. Sprays should be applied in January and February before the eggs hatch.

Fruit Tree Leaf Roller, *Tortrix argyrospila* (Walk.) (*Archips*).—The eggs are laid in small, flat, grayish or brownish masses (fig. 10), usually on two- or three-year-old growth in the middle near the tops of the trees, in the fall. They hatch in the spring; and the caterpillars draw the leaves together into compact rolls in which they live, and from which they wriggle violently if disturbed. When mature the caterpillars are nearly ¾ inch long, deep green, with the head and thoracic shield dark brown or black. The most satisfactory means of control is directed against the eggs and consists in the use of a 4 per cent emulsive or tank-mix oil or 5 per cent oil emulsion spray during the winter. Great care must be taken to thoroughly drench the limbs and particularly the tops and outside branches.

Eye-spotted Bud Moth, *Spilonota ocellana* (D. & S.).—This insect overwinters as half-grown, brown larvae in silken cases in the crotches of twigs. In the spring these worms emerge and feed on the opening buds. They give rise in midsummer to moths, which lay eggs. A late-summer brood of young worms, produced from these eggs, attacks the green and ripening fruit, feeding externally. Spray in midwinter with 6 gallons of oil emulsion plus 1 quart of nicotine sulfate per 100 gallons of water; or use 2½ gallons of a commercial solution of dinitro-*o*-cyclohexylphenol in winter-grade type spray oil per 100 gallons of water; or use 2 gallons of winter oil plus 1 gallon of a commercial solution containing 20 per cent sodium dinitro-*o*-cresolate per 100 gallons of water.

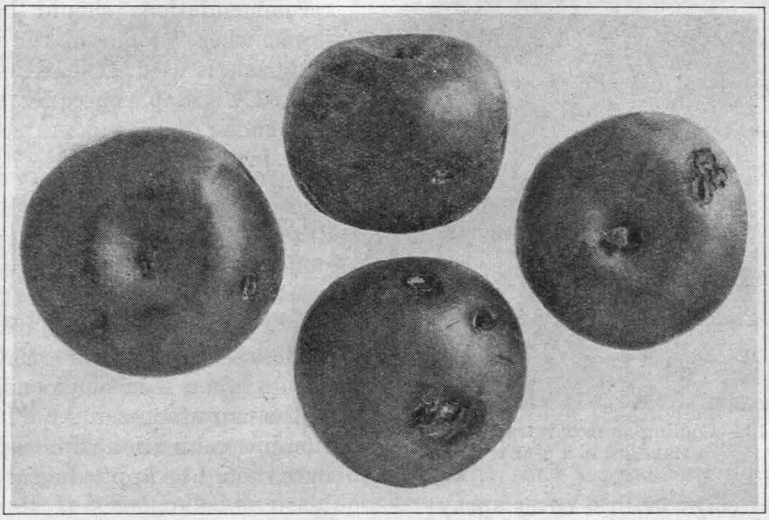


Fig. 11.—Mature apples showing exit holes of the caterpillars of the codling moth, *Carpocapsa pomonella* (Linn.).

Codling Moth, *Carpocapsa pomonella* (Linn.).—The codling moth (figs. 11 and 158, p. 134) is the most important insect occurring on apple and pear and requires a complete spray program properly timed for its control. The number of spray applications required depends upon the moth population in each orchard. Increases in moth population may be prevented by the destruction of overwintering larvae by means of orchard sanitation and banding.

Efficient spray control of the first or spring brood is most important in preventing losses from second-brood attack later in the season. Two calyx sprays thoroughly applied under low pressure (200 to 300 pounds) and a large volume of spray are recommended. The first spray should be applied when 50 per cent of the petals are off, and the second calyx spray 10 days later. The formula recommended in these two sprays is:

Powdered standard lead arsenate	4 pounds
Water	100 gallons

Use of spreader optional—lime caseinate type preferred

Subsequent spring and summer sprays should be timed by the bait-trap method[7] (see formula 35, p. 182; also fig. 12); at most there should be two applications at intervals of not over 15 days in the first brood (April to June), and one to three applications at intervals of 14 to 21 days in the second brood (July to September). In these cover sprays, either lead arsenate or some one of the substitute materials such as cryolite, nicotine-bentonite, or xanthone may be used. The manufacturer's recommendations should be followed wherever one of the newer materials is used. If lead arsenate is used, a suitable spreader, as recommended by the manufacturer, is desirable. The formula with lead arsenate is:

Powdered standard lead arsenate[8]	3 pounds
Spreader as recommended by manufacturer	
Water	100 gallons

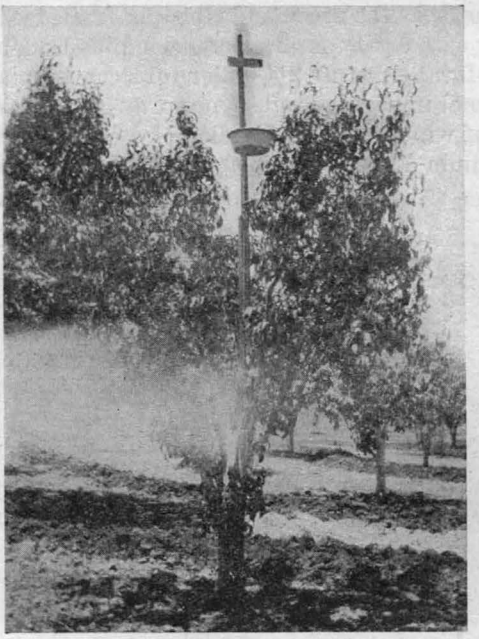


Fig. 12.—Codling-moth bait trap suspended on a standard in a pear tree.

Dosage of substitute materials should follow the recommendations of the manufacturer. An oil emulsion in combination with lead arsenate should be applied only in the second calyx or first cover spray; if applied later there may be difficulty in spray-residue removal.

The scraping of loose rough bark from the trunk and scaffold limbs of apple trees and the application of chemically treated bands in May are important means of destroying the overwintering larvae. Excellent aids to orchard sanitation are thinning of fruit clusters, frequent removal and disposal of windfalls and dropped fruit from the orchard, the screening of packing sheds, and the treatment of infested fruit boxes.

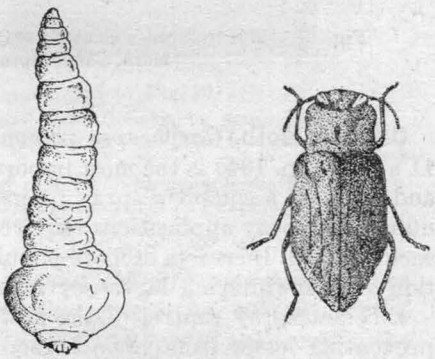


Fig. 13.—Western flat-headed borer, *Chrysobothris mali Horn, larva and adult.* (About three times natural size.) (After Woodworth.)

[7] See: Borden, Arthur D. Codling moth bait traps. California Agr. Ext. Cir. 63:1–13. 1932. (This circular is out of print but may be consulted in many city and county libraries in California.)

[8] In the coastal areas, the use of standard lead arsenate is not recommended after the latter part of May due to possible foliage and fruit injury. One of the substitute materials may be employed.

Western Flat-headed Borer, *Chrysobothris mali* Horn.—The full-grown larvae, or borers, are white or pale yellow and vary from ½ to 1 inch in length. As shown in figure 13, the portion just behind the head is greatly enlarged and flattened, a character which is responsible for the common name. The adult beetles lay eggs on sunburned or other dead areas of the trunk exposed to the sun. Whitewash trunks to prevent sunburn and repel egg laying. Avoid injuries and wounds. Dig out borers and paint with asphaltum. Apply soap and naphthalene repellent (formula 9, p. 163) early in the spring when leaves start and repeat in 3 or 4 weeks.

APRICOT

(See also "Dried Fruits," p. 65, and "Nuts in Storage," p. 87)

Combined Spraying.—General cleanup may be accomplished by dormant oil sprays, 5 per cent commercial oil emulsion, 4 per cent emulsive oils, or 4 per cent tank-mix oil sprays (p. 166). To control peach twig borer and brown rot, see the program recommended under "Peach Twig Borer."

Mealy Plum Aphid.—See under "Plum and Prune" (p. 104).

Brown Apricot Scale, *Lecanium corni* Bouché, **and Black Scale,** *Saissetia oleae* (Bern.).—Immature scales of both species are brown or grayish, the latter having a distinct "H" on the back. They mature in May and June and are nearly hemispherical; the former (fig. 9, p. 12), sometimes called "European fruit lecanium," is smooth and brown, and the latter black. Control is directed against the immature winter forms which occur on the new growth. Spray the trees when dormant, December to February, with 4 per cent commercial oil emulsion or 3 per cent tank-mix oil sprays (p. 166), or emulsive oils, all of which give excellent control for both of these scales. Thoroughness of application is necessary.

Olive Scale, *Parlatoria oleae* (Colvée).—This scale may cause staining of the fruit. It is controlled on deciduous trees by a spray containing 4 per cent dormant oil, or 2 per cent dormant oil and 4 per cent dinitro-*o*-cyclohexylphenol, or 2 per cent dormant oil and 3 pints of 20 per cent sodium dinitro-*o*-cresolate to 100 gallons of water. See under "Olive" (p. 90) for a description of the insect.

Cankerworms.—See page 148.

Fruit Tree Leaf Roller.—See under "Apple and Quince" (p. 12).

Pacific Peach Tree Borer.—See under "Peach and Nectarine" (p. 97).

Peach Twig Borer, *Anarsia lineatella* Zell.—See under "Peach and Nectarine" (p. 97) for a description of the insect. The following method of control is recommended:

For apricots, where the use of lime-sulfur is likely to cause injury and where a combined insecticide and fungicide is desired to control the peach twig borer and brown rot (first spray), use bordeaux mixture 16–16–100 plus 3 pounds of dry basic lead arsenate to every 100 gallons of the spray mixture. Apply this spray at the red-bud stage. Summer sprays with arsenicals should not be applied without consultation with competent authorities.

Red-humped Caterpillar.—See under "Plum and Prune" (p. 104).

This caterpillar is usually injurious to apricots only in the late fall, when control measures are hardly necessary.

Branch and Twig Borer, *Polycaon confertus* Lec.—A small, elongated brown beetle (fig. 14), ¼ inch long, bores clean round holes at the bases of buds, fruit spurs, and in the forks of small twigs. It often makes severe pruning necessary. The insect breeds in dead oaks and other native trees and in prunings of fruit and other trees. Clean up and burn dead brush and prunings around orchards.

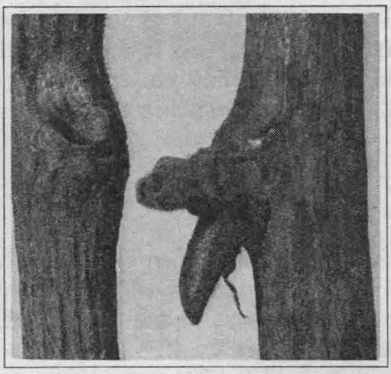


Fig. 14.—The branch and twig borer, *Polycaon confertus* Lec., burrowing into an apricot twig on the right; on the left, a previously made hole. (About twice natural size.)

Western Spotted Cucumber Beetle, *Diabrotica 11-punctata* Mann. — This common small beetle (fig. 101, p. 85), which has green elytra with black spots, sometimes seriously attacks the ripening fruit. The beetle population builds up in the uncultivated areas, and, as the vegetation dries, the insects migrate into the orchards. Only orchards adjacent to uncultivated areas are liable to be seriously attacked. The insect eats holes in the ripening fruit and is also very important in spreading the brown-rot organism. Where serious infestation develops, the ripening fruit can be protected by dusting the trees with a pyrethrum-thiocyanate dust containing 0.1 per cent pyrethrin and 1.0 per cent Lethane in talc, at the rate of 50 pounds per acre. The dust should be applied at a temperature of less than 65° F. Because very small amounts of the dust will knock the insects out of the tree but will not kill them, a tree row can be effectively dusted from only one side, and the duster must develop enough velocity and volume to push the dust entirely through the tree with a single application. For the same reason, the dust drift must be into the already treated area, and consecutive rows should be taken. If the wind changes so that the drift is into the nondusted portion of the orchard, dusting must be discontinued. If these precautions are not taken, insects that have been knocked out of the trees with a sublethal dose will recover as the temperature rises in the morning and will fly back up into the trees.

Shot-Hole Borer,[9] *Scolytus rugulosus* Ratz., **and Lesser Shot-Hole Borer,** *Xyleborus saxeseni* (Ratz.).—These are very small brown beetles (fig. 15), 3/32 inch in length, which bore into the sapwood and heartwood of fruit trees, particularly prunes, plums, apricots, and cherries, preferring the trees in imperfect health. The white larvae of the shot-hole borer may be found during the winter months in the sapwood just beneath the bark, where they may completely girdle the trees. Keep trees well cultivated, fertilized, and irrigated throughout the year; prune out and burn all dead wood and trees to prevent spread; destroy all prunings immediately. Orchards can be freed of this pest if they are properly irrigated and beetle-infested wood is carefully removed. Beetles cannot breed in wood which has been cut for more than one year. Trees in abandoned orchards are favorite breeding places and should be removed.

[9] See: Smith, Leslie M. The shot-hole borer. California Agr. Ext. Cir. 64:1–13. 1932. (This circular is out of print but may be consulted in many city and county libraries in California.)

ARTICHOKE

Gray Garden Slug, *Deroceras agreste* (Linn.), **and the Greenhouse Slug,** *Milax gagates* Drap.—These slugs often cause severe injury to artichoke heads by their feeding on the outer bracts. Damage is more severe during the winter and spring, although under coastal conditions injury can occur throughout the year. For control see "Slugs and Snails" (p. 138). The poison baits should be applied at the rate of 20 pounds per acre in small piles near the center of the plants. Cultivation between the plants will assist in reducing the number of slugs.

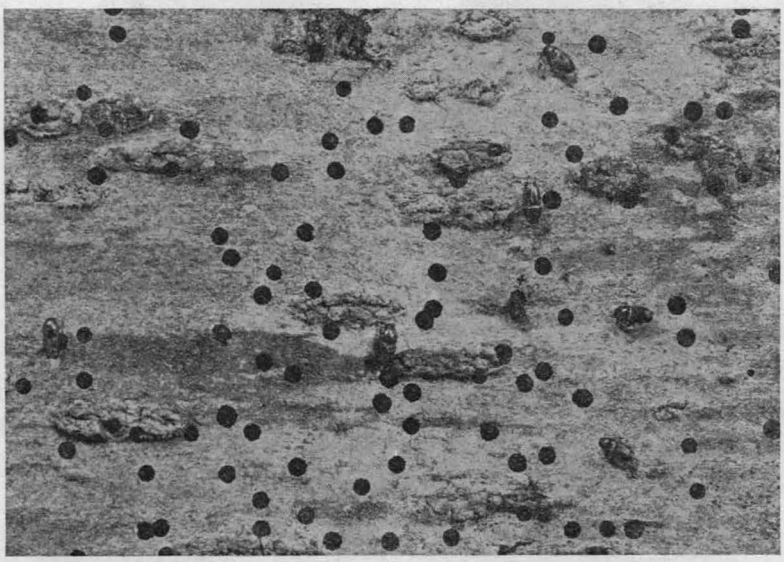


Fig. 15.—The shot-hole borer, *Scolytus rugulosus* Ratz., and exit holes on prune tree.

Bean or Dock Aphid, *Aphis rumicis* Linn., **and the Artichoke Aphid,** *Myzus braggii* Gill.—These aphids often occur in large numbers and may greatly injure garden plantings. For a description of the bean aphid, see under "Bean" (p. 25). The artichoke aphid, pale yellow to green with darker-green markings, often occurs in large numbers on the undersides of the leaves and seriously stunts the growth of the plants. The secretion of honeydew causes a later smutting of the heads. Dust with 4 per cent nicotine dust or 1 per cent rotenone dust at the rate of 20 to 50 pounds per acre, the amount depending upon the size of the plants.

Artichoke Plume Moth, *Platyptilia carduidactyla* (Riley).—The moth has characteristic divided wings, is buff brown, and attains a wing expanse of 1 inch. The caterpillars feed on the tender new foliage and mine inside the stems, leafstalks, and buds. Where they feed on the bracts or bore into the developing flower parts, noticeable damage occurs to the heads (fig. 16). Three overlapping generations occur each year, with all stages overwintering.

Damage is usually most severe during the spring. A combination of field sanitation and cultural practices offers the best means of control. These methods include the picking and destruction of all wormy artichokes, especially during the spring months; the burying of all plant tops in a ditch

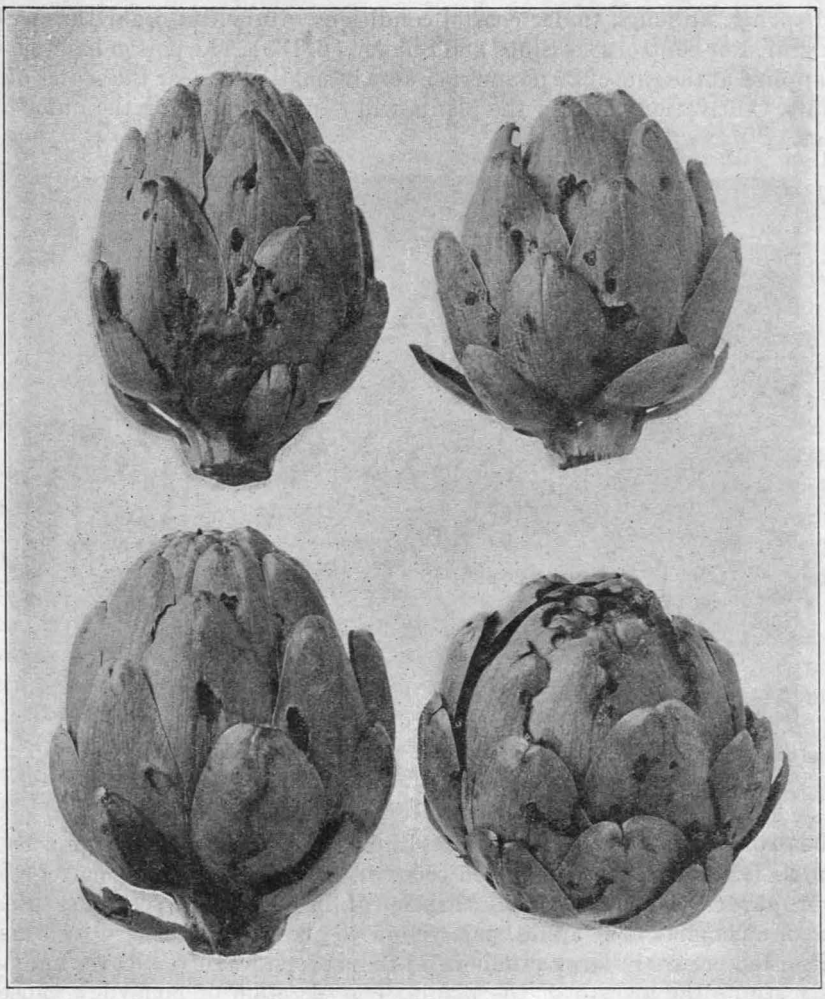


Fig. 16.—Damage to artichoke heads caused by larvae of the artichoke plume moth, *Platyptilia carduidactyla* (Riley).

between the rows, covered with at least 12 inches of soil; the use of "clean" planting stock; use of proper rotational systems; and the removal of all thistles of the genus *Cirsium* and old cardoon or artichoke plants near plantings. Chemical control has not proved satisfactory in commercial plantings. In garden plantings the use of a pyrethrum and oil spray (formula 18, p. 172) applied at frequent intervals will give some control.

ASPARAGUS

Garden Centipede, *Scutigerella immaculata* (Newp.).—The adults are small, white, centipedelike animals (fig. 17), scarcely more than ¼ inch long. They live in the damp soil in great numbers and often seriously damage the asparagus spears before the latter have reached the surface. They sometimes seriously attack newly planted fields, which results in poor stands. Winter flooding is the best means of control. Land suspected of being infested should be summer-flooded before asparagus is planted. Clean culture and crop rotation are helpful in checking the pest.[10]

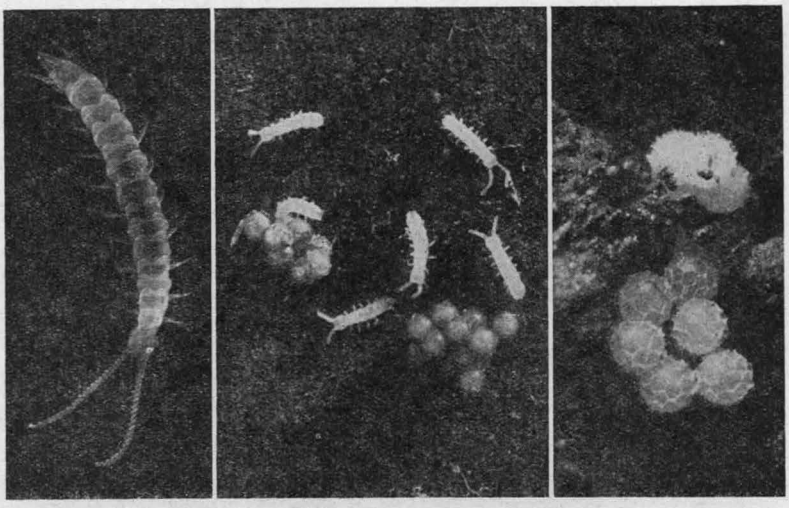


Fig. 17.—The garden centipede, *Scutigerella immaculata* (Newp.). Adult, eggs and newly hatched young, and eggs much enlarged. In natural size, the adults are about ¼ inch long. (After Wymore.)

Asparagus Beetle, *Crioceris asparagi* (Linn.).—The beetles are slender, ¼ inch long, metallic blue black with red and yellow markings. The larvae are dull brown or olive green with black head and legs. They feed in great numbers upon the seedlings. Control by clean culture, by cutting and burning seedlings, or by spraying them with nicotine and soap spray (formula 16, p. 171). A straight calcium arsenate dust, a 2 per cent nicotine dust, or a 25 per cent calcium cyanide dust also gives very efficient control. See figure 18.

ASTER

Callistephus chinensis (Nees)

Two-spotted Mite.—See under "Bean" (p. 23).

Aster Leafhopper, *Macrosteles divisus* (Uhler).—This leafhopper is about ⅛ inch long and yellow or yellowish green with black spots on the back. It

[10] See also: Wymore, F. H. The garden centipede. California Agr. Exp. Sta. Bul. 518:1–22. 1931. (This bulletin is out of print but may be consulted in many city and county libraries in California.)

Michelbacher, A. E. Chemical control of the garden centipede. California Agr. Exp. Sta. Bul. 548:1–19. 1932.

carries a disease of asters known as "aster yellows," the symptoms of which are: the young leaves with transparent venation, erect; plants irregularly chlorotic (yellow), stunted, with abnormal branches; and flowers with part or all petals green. The disease is carried over not in the seed of the plants or the eggs of the insect, but in some diseased perennial plants. Numerous garden plants and weeds are affected. In lettuce it causes the white-heart disease. It was formerly rare in California though common in the East. No control is known. Herbaceous plants brought from the East should be watched, and

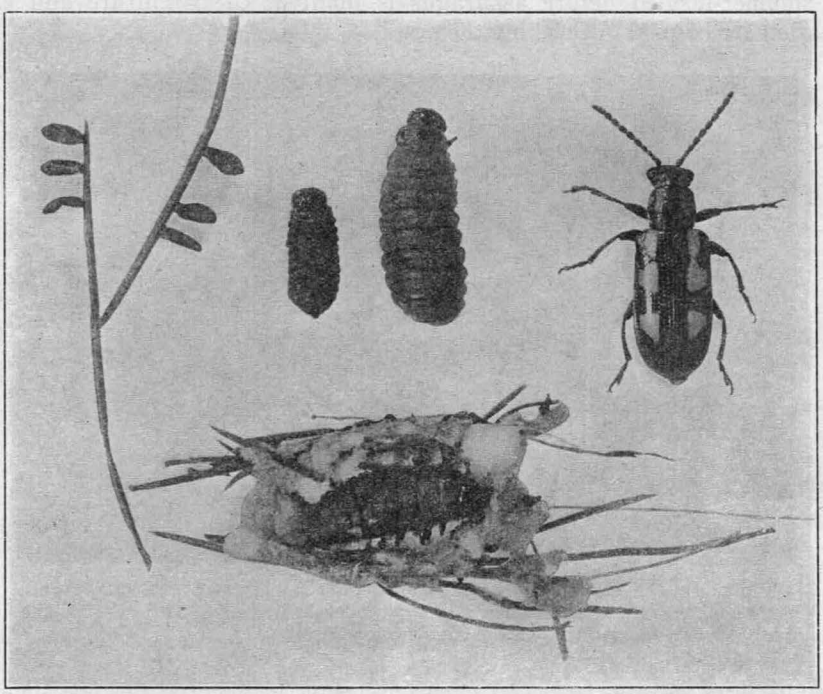


Fig. 18.—The asparagus beetle, *Crioceris asparagi* (Linn.). Eggs attached to asparagus leaflets, larvae, adult, and larva in cell. (Greatly enlarged.) (After Wymore.)

suspicious ones destroyed. Any herbaceous perennials which appear abnormal should be destroyed. Other plants in California known to be subject to natural infection are celery, California poppy, African marigold, Hamburg parsley, Short White carrots, White Belgian carrots, and zinnia.[11]

Aster Root Aphid, *Anuraphis middletonii* (Thos.).—This dark green aphid often occurs in such numbers on the roots of aster plants as to kill them. Watering liberally with nicotine sulfate 40 per cent, diluted 1 part to 600 parts of water, or with carbon disulfide emulsion, 1 part to 300 parts of water, will control the pest. The aphids may be parasitized by another insect (the hymenopterous parasites, species of *Incubus*) and then appear as pale inflated bodies.

[11] See: Smith, Ralph H. Diseases of flowers and other ornamentals. California Agr. Ext. Cir. 118:8. 1940.

AVOCADO[12]

Avocado Brown Mite, *Paratetranychus coiti* McG.—"Brown" indicates not only the general color of this mite but also the color of the leaves and fruit that result from its feeding. Dusting with sulfur is satisfactory for control.

Greenhouse Thrips, *Heliothrips haemorrhoidalis* (Bouché).—This insect attacks the leaves and fruit and gives them a hard, shiny, light-brown surface

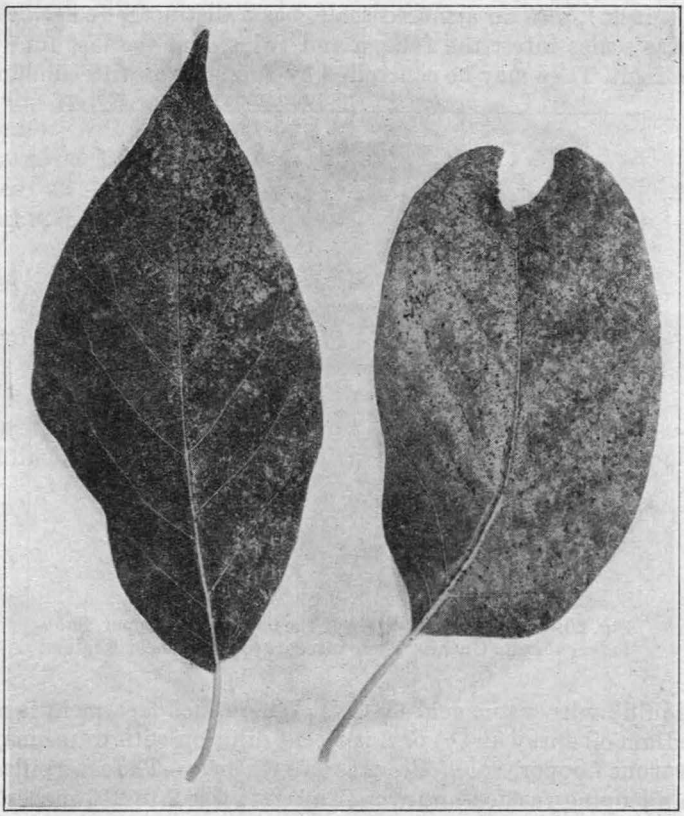


Fig. 19.—Greenhouse-thrips injury to avocado leaves. The light areas are portions where the cell contents have been sucked out by the thrips. The black dots are excrement. (From Cir. 346.)

which has a tendency to crack and which is covered with small particles of dark excrement (fig. 19). Infestations generally occur in limited areas and sometimes on only a portion of the tree. A pyrethrum or pyrethrum and oil spray (formula 18, p. 172) is the most satisfactory treatment.

Mealybugs.—See page 142.

Scale Insects.—Black scale, *Saissetia oleae* (Bern.), and soft brown scale, *Coccus hesperidum* Linn., are naked, unarmored scales, lacking a protective shell or covering. The former is dark brown to black in color with a more or less

[12] For further details see: McKenzie, Howard L. Biology and control of avocado insects and mites. California Agr. Exp. Sta. Bul. 592:1–48. 1935.

distinct letter "H" on the dorsum and is nearly globular in form when fully developed. The latter is a thin, flat, oval, transparent, yellowish-green or brown scale. Greedy scale, *Hemiberlesia rapax* (Comst.), ivy or oleander scale, *Aspidiotus hederae* (Vall.), and latania scale, *Aspidiotus destructor* Sign. (*A. lataniae* Sign.), have grayish-white or yellowish shells, or scales, covering the yellow bodies and are called "armored scales." The last-named is by far the most serious scale pest of the avocado. Red scale, *Aonidiella aurantii* (Mask.), also an armored scale, has a distinctly red scale covering. All of these scales infest the foliage and twigs, and the last four may also infest the fruit. They may be controlled by fumigation with calcium cyanide

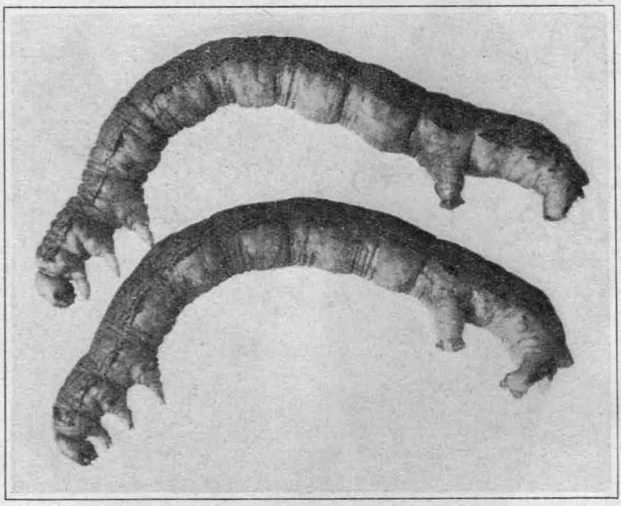


Fig. 20.—Mature caterpillars of the omnivorous looper, *Sabulodes caberata* Guénée. These insects are ravenous leaf eaters.

dust or liquid hydrocyanic acid (HCN). Where such treatment is not practical, a medium oil spray at 1½ or 2 per cent dilution with water may be used.

Omnivorous Looper, *Sabulodes caberata* Guénée.—The caterpillar (fig. 20) moves in a looping fashion and when full grown is 2 to 2½ inches long. The adults are beautiful fawn-colored moths that rest on flat surfaces with the wings fully spread. They fly at dusk and night. Outbreaks of large numbers occasionally occur and cause severe defoliation of the trees. In such cases the caterpillars should be detected while they are still small (spring and summer) and a spray of lead arsenate (formula 1, p. 156) applied.

Amorbia, *Amorbia essigana* Busck.—The small caterpillars web the leaves together, and actively wriggle out from the web when exposed. They are dark green and grow to a length of 1 to 1½ inches. The moths are brown or tawny in color. Injury consists of irregular scarred areas on the fruit and skeletonizing of the leaves. Treatment is usually not necessary. When the insect is injurious, standard lead arsenate (formula 1, p. 156) may be applied.

BARLEY

(See "Grain," p. 71)

BEAN

(See "Stored Cereals and Beans," p. 114)

Root-Knot Nematode.—See "Nematodes or Eelworms" (p. 136). Blackeye cowpeas and tepary beans are more resistant than other beans, but are sometimes badly infested.

Two-spotted Mite, *Tetranychus bimaculatus* Harvey, **and the Pacific Mite,** *T. pacificus* McG.—These are very small, yellow, pale-green or reddish mites, with or without two or more large dark spots on the body. They feed on the undersides of leaves and spin a considerable web. If possible keep the beans well irrigated and cultivated and in good healthy condition. Begin dusting with sulfur as soon as the mites appear and continue throughout the summer, using 90 parts of dry sulfur to 10 parts of finely ground dry hydrated lime, or straight dusting sulfur. Some care in time of application is

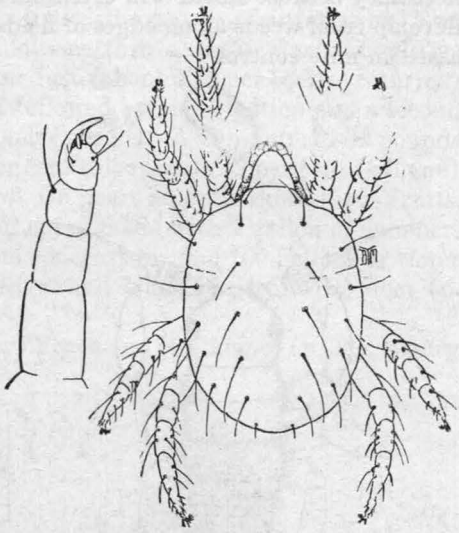


Fig. 21.—The adult two-spotted mite, *Tetranychus bimaculatus* Harvey

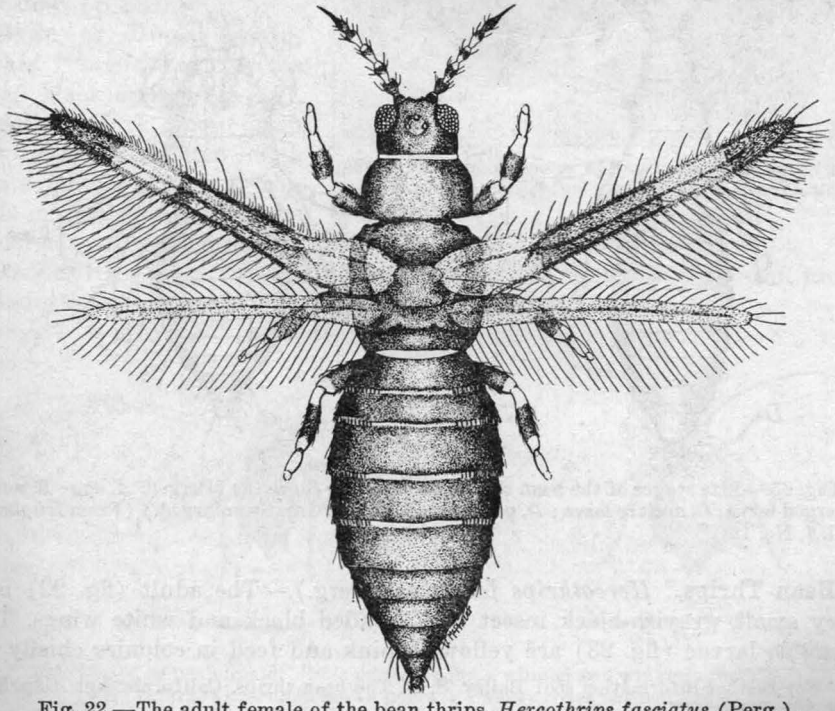


Fig. 22.—The adult female of the bean thrips, *Hercothrips fasciatus* (Perg.). (Seventy-five times natural size.) (From Bul. 609.)

necessary because sulfur will often burn the flowers. Since infestations often develop from weeds along edges of fields, the cleaning up of these sources will assist in mite control.

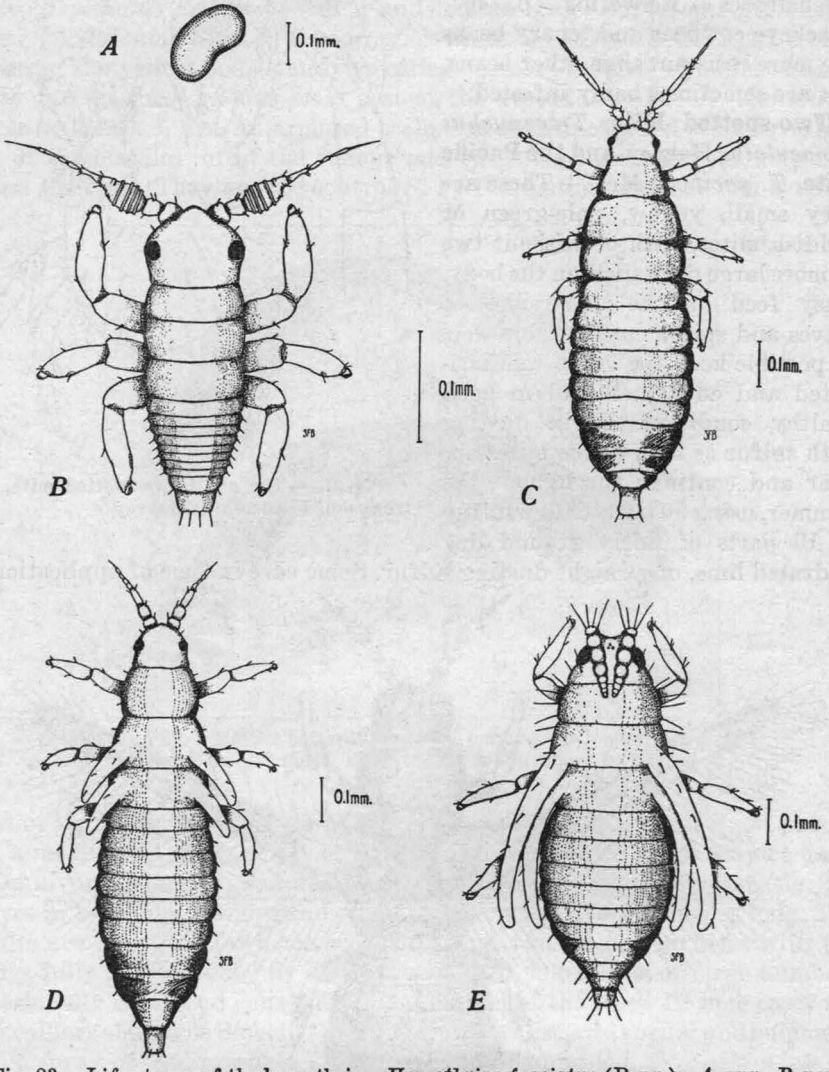


Fig. 23.—Life stages of the bean thrips, *Hercothrips fasciatus* (Perg.): *A*, egg; *B*, newly emerged larva; *C*, mature larva; *D*, prepupa; *E*, pupa. (Greatly enlarged.) (From *Hilgardia* Vol. 7, No. 12.)

Bean Thrips,[13] *Hercothrips fasciatus* (Perg.).—The adult (fig. 22) is a very small, grayish-black insect with banded black and white wings. The sluggish larvae (fig. 23) are yellowish pink and feed in colonies chiefly on

[13] For further information see: Bailey, S. F. The bean thrips. California Agr. Exp. Sta. Bul. 609:1–36. 1937.

Bailey, S. F. Thrips of economic importance in California. California Agr. Exp. Sta. Cir. 346:33–39. 1938.

the lower leaf surface. Weed control in and about fields and orchards in the spring and early summer largely eliminates the source of infestation. Two host plants, prickly lettuce and annual sow thistle, particularly should be destroyed. On annual crops, pyrethrum dust (about 0.25 per cent pyrethrins) gives excellent results, particularly if followed by an irrigation and a second application of the dust about 10 days after the first. A minimum of 30 pounds of dust per acre should be used. A 1 per cent thiocyanate (2 per cent Lethane) commercial dust also gives good control. On pears and other deciduous fruits, the application of a pyrethrum and oil spray made with 1 gallon of summer-type oil emulsion, ⅔ pint of pyrethrum concentrate, and 100 gallons of water readily kills all active forms on the leaves and fruit. Dinitro (DN) dust (p. 160) may also be used if available.

Flower or Grass Thrips.—See under "Peach and Nectarine" (p. 95). Injury to bean leaves caused by this insect is shown in figure 24.

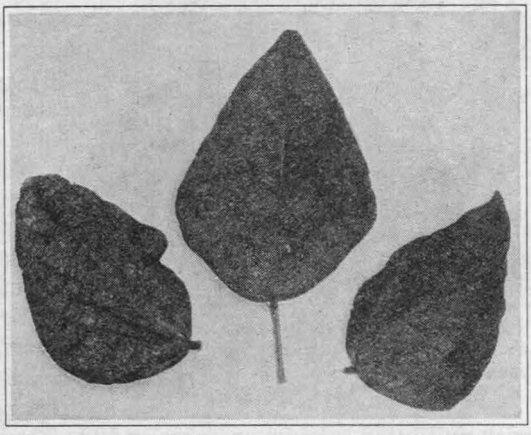


Fig. 24.—Bean leaves showing injury due to the feeding of the flower or grass thrips, *Frankliniella moultoni* Hood.

Onion Thrips, *Thrips tabaci* Lind.—Occasional infestations of this thrips occurs on beans. For control see under "Onion, Garlic, Leek, Shallot" (p. 92).

Western Plant Bug, or Cotton Dauber.—See under "Cotton" (p. 58).

Bean or Dock Aphid, *Aphis rumicis* Linn.—This small black aphid (fig. 25), sometimes dark green, often has nymphs spotted with white powdery wax. It collects in great numbers on the undersides of the leaves and on tender tips. When this aphid becomes injurious dust with 4 per cent nicotine dust at the rate of 20 to 30 pounds per acre.

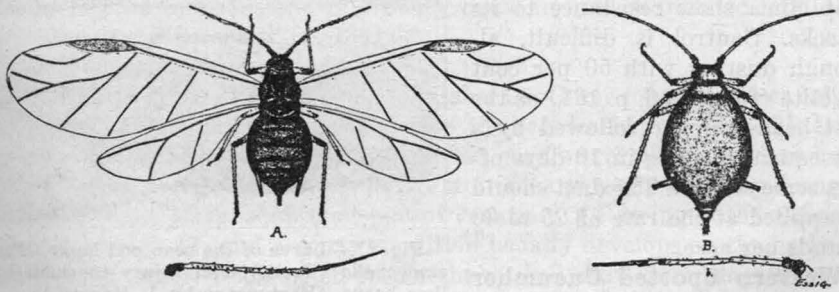


Fig. 25.—The bean aphid, *Aphis rumicis* Linn.: winged and wingless females, with enlarged antennae shown below. (Twenty times natural size.)

Glacial Whitefly, *Trialeurodes glacialis* (Bemis).—The immature forms are pale yellow and somewhat covered with fine white powdery wax. They live mostly on the undersides of the leaves. The adults are pure-white, tiny flies that may occur abundantly over the foliage. They fly readily when disturbed. Control consists in spraying with a 1 per cent highly refined light summer-type oil emulsion to which is added pyrethrum concentrate, 1 part to 300 parts of the diluted oil emulsion. The work must be carefully and thoroughly done to kill the young on the undersides of the leaves.

Fig. 26. — The woolly bear caterpillar, *Estigmene acraea* (Drury), and injury to bean plant.

Woolly Bear Caterpillar, *Estigmene acraea* (Drury).—Often severe losses are caused by the feeding (fig. 26) of these large, woolly, brown caterpillars. Dusting with undiluted calcium arsenate or 50 to 70 per cent cryolite in talc offers some control; but either, if applied after the pods form, must be washed from snap beans for market or canning.

Cutworms.—See page 144.

Corn Earworm or Tomato Fruitworm, *Heliothis armigera* (Hbn.).—Beans are occasionally attacked by this pest. Control consists of dusting with undiluted calcium arsenate or 50 to 70 per cent cryolite in talc. Residues must be removed as discussed under "Woolly Bear Caterpillar."

Bean Pod Borer, *Etiella zinckenella* (Treit.).—The caterpillars of this small gray moth burrow into the developing seeds of lupines and beans (fig. 27). Some strains of Hopi lima show resistance to its attacks. Control is difficult, although dusting with 50 per cent cryolite (formula 6, p. 161) as the first beans appear followed by a subsequent dusting in 10 days offers some control. The dust should be applied at the rate of 25 to 30 pounds per acre.

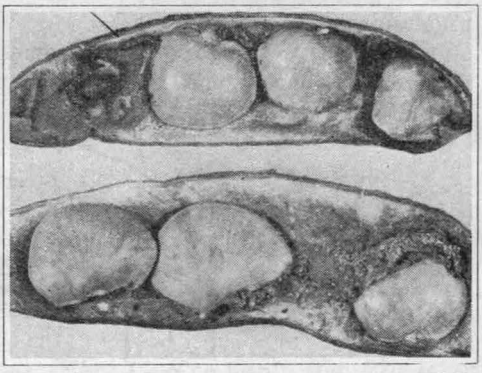


Fig. 27.—Larva of the bean pod borer, *Etiella zinckenella* (Treit.), and injury to small bush lima beans. (Photograph by A. Hansen.)

Western Spotted Cucumber Beetle, *Diabrotica 11-punctata* Mann.—This common green beetle with black spots often attacks beans in great numbers. Control consists of a 50 per cent cryolite dust (formula 6, p.

161) at the rate of from 25 to 40 pounds per acre, or a pyrethrum and thiocyanate dust containing 0.1 per cent pyrethrins and 1.0 per cent Lethane. This latter dust should be applied during temperatures of from 50° to 65° F to obtain best results. See under "Melons" (p. 83).

BEET

Root-Knot Nematode, *Heterodera marioni* (Cornu), **and Sugar-Beet Nematode,** *Heterodera schachtii* Schmidt.—The former is very widely distributed and produces galls on the roots of beet and a great variety of other

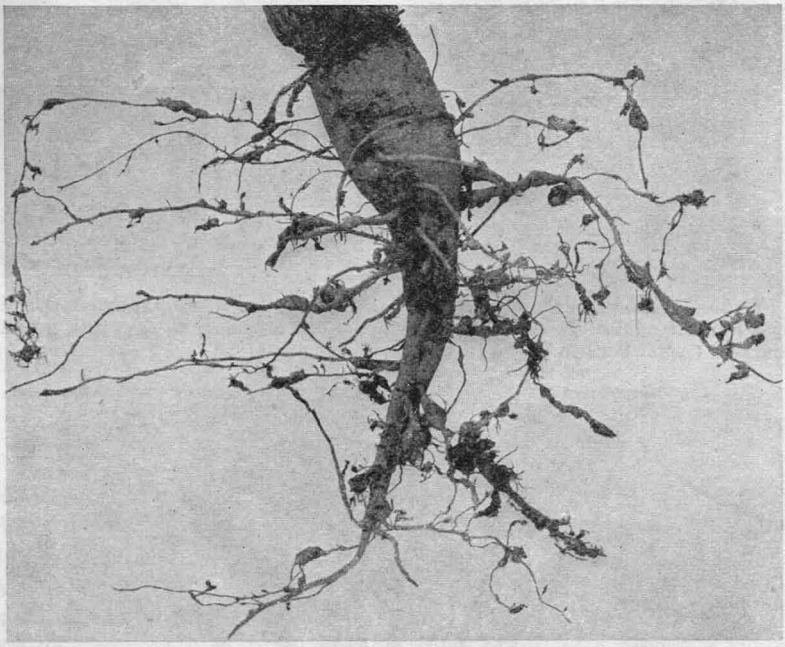


Fig. 28.—Nodules on the small rootlets of sugar beet caused by the sugar-beet nematode, *Heterodera schachtii* Schmidt.

plants. The latter (fig. 28) confines its attacks chiefly to sugar beets. Control consists in crop rotations and in growing beets on new, uninfested land. See "Nematodes or Eelworms" (p. 136).

Grasshoppers.—See page 142.

Beet Leafhopper, *Eutettix tenellus* (Baker).—Curly top, sometimes called "curly leaf" or "blight," is transmitted by the beet leafhopper (fig. 29). Leaf margins on curly-top plants (fig. 30) curl inward or rarely outward and are much dwarfed and deformed; plants are stunted, and easily killed by drought and heat; young leaves show transparent venation (a clearing of the ultimate leaf vein branches); and a warty condition usually develops on the backs of veins on old leaves. Roots often become hairy and show dark rings in cross section.

In the cool districts subject to ocean fogs, the insects do not reproduce abundantly and the disease when established is less injurious. Beets in all

other parts of the Pacific slope and of the Rocky Mountains are liable to injury, but in certain regions have been observed to suffer less than in others. Early planting (December to March 1 in interior regions), to bring the beets

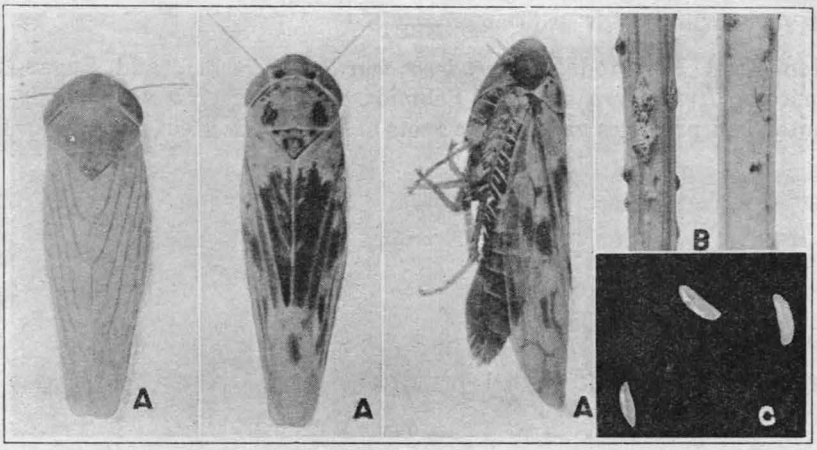


Fig. 29.—The beet leafhopper, *Eutettix tenellus* (Baker): *A*, light and dark color phases of the adults; *B*, egg punctures in the leaf petioles; *C*, eggs; all greatly enlarged. (After Severin.)

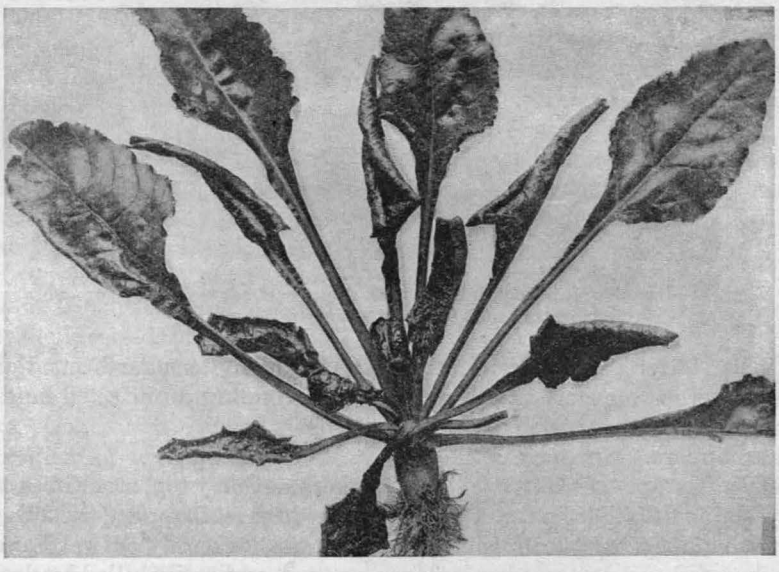


Fig. 30.—Young sugar beet infected with curly-top disease. (After Severin.)

to a good size before the spring invasion of the insects from plains and foothills, is generally successful except in years following early fall rains, which bring up filaree and other vegetation and cause a large number of insects to winter in the cultivated area. In the fog belt and coast valleys of central California, early planting, then cessation, then resumption of planting in May and June

is recommended.[14] Blighted stecklings do not produce seed successfully, although the symptoms may not always be apparent.

The beet leafhopper is wingless in the immature form and winged when full grown. The adults average about ¼ inch in length. The color varies with the season, those of the spring brood being pale green, those of the summer brood cream-colored, and the winter, hibernating forms dark-colored with darker markings on the wing covers. The insects are to be found chiefly on the undersides of the leaves or between the stems near the crown. Their feeding introduces the virus which causes the characteristic curly top. A pyrethrum-oil spray has been developed for the control of this insect in cultivated sugar-beet fields, but is likely to prove to be too expensive for practical purposes. Preparations of pyrethrum and oil are also used to kill the hibernating forms in the breeding grounds of the foothills.

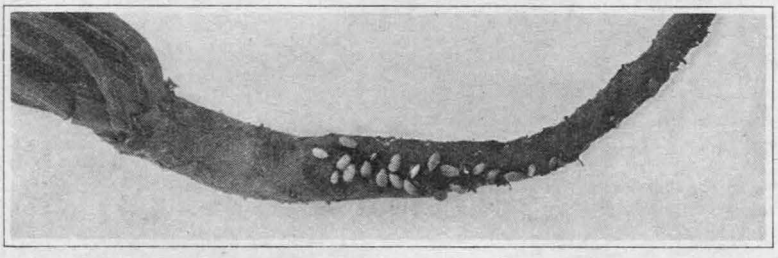


Fig. 31.—The beet aphid, *Prociphilus betae* (Doane), on the root of young beet. (Photograph by Severin.)

Beet Aphid, *Prociphilus betae* (Doane) (*Pemphigus*).—The apterous root-infesting forms are minute, pale insects (fig. 31), more or less covered with fine, fluffy, cottony wax, which at once indicates their presence. They feed upon the roots and rootlets and are able to survive in the soil on roots left in the fields after harvest; in this way, they can immediately infest a new crop on land previously planted to beets. This aphid also feeds on the roots of various species of dock and is reported to maintain itself on other weeds in cultivated and noncultivated areas. Dark-winged individuals appear in the fall and spring, fly to other fields and plants, and thus infest newly planted beets. Usually the first year's crop is but slightly injured; losses, however, increase as the fields are successively planted to beets. The most important method of control is crop rotation, planting beets one or more years, and then some other crop for a like period of time.

Beet Armyworm, *Laphygma exigua* (Hbn.).—Mature caterpillars (fig. 32, *C*) are 1 to 1¼ inches long, pale olive green with a dark middorsal stripe and pale-yellowish side stripes. The reddish-brown pupae, or chrysalids, are hidden in the soil at the bases of the infested plants. The moths (fig. 32, *A, B*) are mottled gray with lighter markings and have a wing expanse of 1 to 1¼ inches. The caterpillars are often destructive to seedlings but also feed upon older

[14] See: Adams, R. L. The sugar beet in California. California Agr. Exp. Sta. Cir. 302:1–34. 1926. (This circular is now out of print but may be consulted in many city and county libraries in California.)
Smith, Ralph E. Diseases of field crops. California Agr. Ext. Cir. 121:1–79. 1941.

plants of beets, cotton, and many other cultivated crops and weeds and grasses. For control see "Armyworms and Cutworms" (p. 144).

Sugar-Beet Wireworm, *Limonius californicus* (Mann.), **and the Ash-winged Click Beetle,** *Anchastus cinereipennis* (Esch.).—The larvae are the characteristic yellowish, smooth, shiny worms found killing young beet seedlings, more particularly in the spring of the year. When fully grown they are from ½ to 1 inch in length. The adults are active, brownish or blackish click

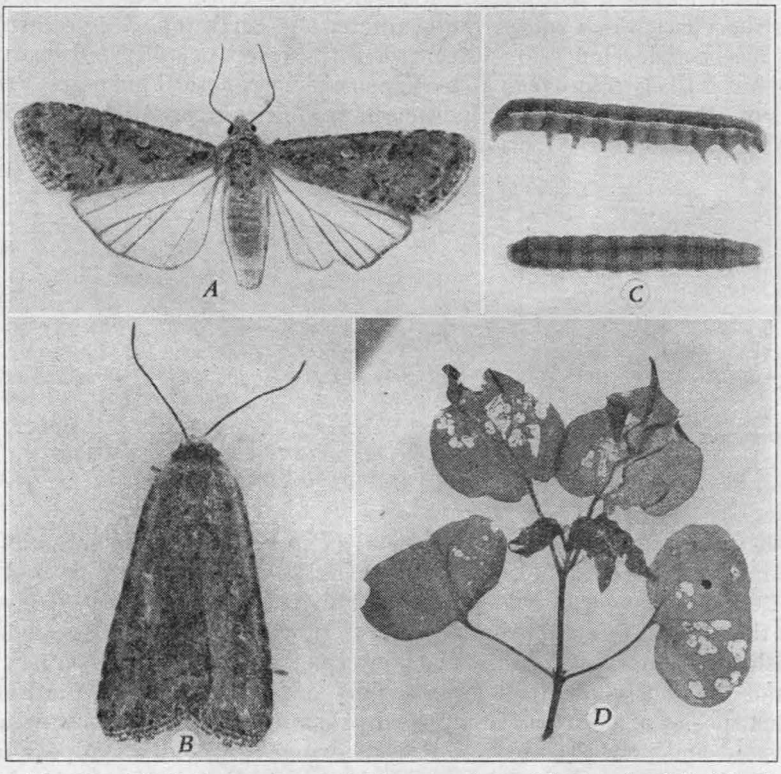


Fig. 32.—The beet armyworm, *Laphygma exigua* (Hbn.): *A*, adult (about twice natural size); *B*, adult at rest (two and a half times natural size); *C*, larvae (one and a half times natural size); *D*, injury to cotton seedling. (From Bul. 660.)

beetles. To reduce injury, practice clean culture, plant early, plow in the fall, and stir ground thoroughly to kill immature forms in the soil. Baits are sometimes used, but are impractical for sugar-beet culture. See figures 77 (p. 64), 177 (p. 150), 178 (p. 150).

Spinach or Beet Leaf Miner.—See under "Spinach" (p. 112).

BLACKBERRY

(See "Bush Fruits," p. 34)

BROCCOLI

(See "Cabbage," p. 37)

BROOM

(*Cytisus* spp., *Genista* spp.)

Bean or Dock Aphid.—See under "Bean" (p. 23).

Oystershell Scale.—See under "Apple and Quince" (p. 8).

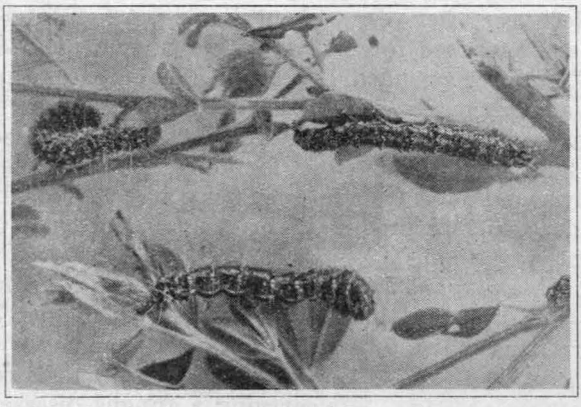


Fig. 33.—Caterpillars of the genista moth, *Tholeria reversalis* Guénée, feeding on broom. (Photograph by McKenzie.)

Genista Moth, *Tholeria reversalis* Guénée.—The caterpillars are orange-green with black and white markings and are covered with tubercles (fig. 33). The adults are snout moths, brown with orange hindwings. The caterpillars web and destroy the foliage and may completely defoliate the plants. For control, dust with cryolite or calcium arsenate or spray with 4 to 6 tablespoons of synthetic cryolite to 1 gallon of water.

BRUSSELS SPROUTS

(See "Cabbage," p. 37)

BUDDLEIA

Buddleia Leaftier, *Pyramidobela angelarum* Keifer.—Buddleia in central and southern California is often heavily infested with the larvae (fig. 34) of this gelechiid moth which web and feed within the terminal leaves. Cryolite applied as a spray at the rate of 4 to 6 pounds per 100 gallons of water offers some control.

Fig. 34.—Type of injury to the terminals of buddleia by the caterpillars of the buddleia leaftier, *Pyramidobela angelarum* Keifer.

BULBS (DAFFODIL, FREESIA, GLADIOLUS, NARCISSUS, TULIP)

(See also "Lily," p. 83)

Narcissus Stem Nematode or Bulb Nematode, *Tylenchus dipsaci* Kühn.—Raised, blisterlike areas appear on the surface of the leaves, and badly diseased plants are lighter-colored and greatly reduced in vigor. The cut bulbs show discolored streaks and rings. Gradually enlarging areas of infestation develop in plantings left year after year without digging. A hot-water treatment, in which bulbs are immersed for 3 hours in water kept at a temperature of 110° to 111.5° F is recommended. It is possible that higher temperatures may be used with advantage. Diseased plants should be destroyed as soon as detected. The remaining bulbs in an infested field should not be sent to market, and infested land should not be used for bulbs for several years. Probably the apparently sound bulbs from infested fields may be treated and grown in clean land and a clean crop produced. This is a new problem in California and is still under investigation.

Bulb Mite, *Rhizoglyphus hyacinthi* Bdv.—This is a whitish or yellowish, slow-moving mite, often with brownish spots on the body (fig. 35). It is most abundant on rotting bulbs, tubers, rhizomes, roots, and decaying vegetable matter generally, and is responsible for carrying a fungus disease, causing rot, from infected to clean bulbs in the soil and in storage. Only clean bulbs should be planted. After digging and curing, dip the bulbs in a 2 to 4 per cent commercial lime-sulfur solution, preferably heated in a large kettle to 125° F for not over 1 minute. Dry and then place in dry, well-ventilated storage. Small lots of bulbs may be effectively treated with a liberal amount of 2 per cent commercial nicotine dust (see p. 171) in paper-bag containers, which may be securely tied; the dust is allowed to remain several days or until the bulbs are ready to plant. This treatment will not only kill the mites, but also thrips, mealybugs, and aphids that may be present.

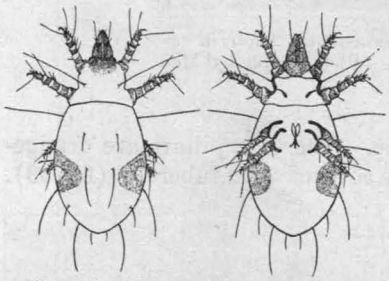


Fig. 35.—Top and bottom views of the bulb mite, *Rhizoglyphus hyacinthi* Bdv., which is transparent whitish, with brown markings as indicated.

Gladiolus Thrips,[15] *Taeniothrips simplex* Morison.—The adults are small, brown and gray. The orange-yellow larvae feed in the buds and leaf sheaths and blast the flowers as they develop. Early planting, immediate removal of the first infested blooms, and burning of plant refuse are important supplementary methods of control. A spray made of 4 pounds of tartar emetic, 16 pounds of brown sugar, and 100 gallons of water (see formulas 21 and 22 and discussion, p. 176) has proved to be the most effective treatment. Repeated applications at about 10-day intervals are often necessary. In addition to field control, proper storage conditions for the corms should be provided, and naphthalene flakes, 1 pound for about 2,000 corms, should be placed in the bulb containers to prevent thrips injury during the dormant period.

[15] Bailey, S. F. Thrips of economic importance in California. California Agr. Exp. Sta. Cir. 346:50–57. 1938.

Green Peach Aphid, *Myzus persicae* (Sulzer).—A yellowish, green, or pinkish aphid often appears in great numbers on tulips, lilies, and other bulbous plants. It attacks chiefly the leaves and tender tips and may curl the foliage and dwarf the plant. It feeds upon a great variety of plant hosts and has a wide distribution in uncultivated and cultivated areas. For control, use pyrethrum and oil sprays (formula 18, p. 172) or oil and nicotine sprays (formula 13, p. 168).

Potato Aphid.—See under "Potato" (p. 105).

Tulip Bulb or Iris Root Aphid, *Aphis tulipae* (B. d. F.).—The wingless forms of this small, pale-green and black aphid are covered with a fine white powdery wax and in this respect resemble the cabbage aphid. This aphid infests many lilaceous plants and feeds in the axils of the leaves, beneath bracts, around the bases of the plants, and on the bulbs and rootstocks in the field and also on the bulbs and rootstocks in storage. In this last case they often do considerable damage. For control in the field, use combinations of pyrethrum and oil (formula 18, p. 172) or oil and nicotine (formula 13, p. 168). In storage, fumigate with nicotine smudges or vaporizing materials such as "Nicofume" or with calcium cyanide dust as recommended for mealybugs. Dipping in hot water, as recommended for nematode, will also kill the aphids.

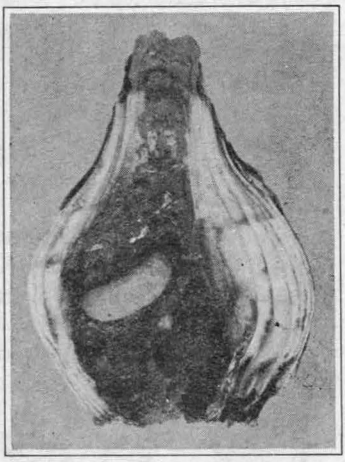


Fig. 36.—The maggot, or larva, of the bulb fly, *Merodon equestris* (Fab.), in a narcissus bulb. The entire heart of the bulb has been destroyed. (After Essig, *Insects of Western North America,* by permission of the Macmillan Co., copyright owners.)

Grape Mealybug, *Pseudococcus bakeri* Essig, **and the Citrophilus Mealybug,** *Pseudococcus fragilis* Brain (*P. gahani* Green).—These flat, oval, mealy-covered insects infest the bulbs in the field and are especially destructive in storage. In the latter case, they may be killed by fumigating with calcium cyanide dust for 2 hours in a tight chamber, the cyanide being used at the rate of 2 ounces per 100 cubic feet of space. The temperature should be 60° to 70° F. See also "Mealybugs" (p. 142).

Bulb Fly, *Merodon equestris* (Fab.).—A large beelike fly gives rise to large whitish or brownish maggots (fig. 36) inside the bulbs of narcissus, amaryllis, hyacinth, galtonia, habranthus, hippeastrum, Spanish iris, lilies, tulips, vallota, onions, and shallots. The adult flies usually appear on warm days in spring and early summer and lay eggs at the bases of the leaves near the center of the bulbs. Control by treating the bulbs in hot water for 2 hours at 110° F or fumigating them with calcium cyanide dust as recommended for mealybugs, after digging or before planting.

Lesser Bulb Fly, *Eumeros strigatus* Fallén.—The maggots, which are about half the size of those of the bulb fly and often occur in the same bulbs, are scavengers which feed upon the decaying tissues caused by the larger species. The control of the bulb fly will eliminate these scavengers from stored bulbs.

BUSH FRUITS (BLACKBERRY, BOYSENBERRY, LOGANBERRY, RASPBERRY)

(See also "Currant and Gooseberry," p. 63)

Blackberry Mite, *Eriophyes essigi* Hassan.—This mite (fig. 37) is too small to be seen without the aid of a microscope. In Himalaya and Mammoth blackberries it causes the "redberry disease," in which some drupelets on a berry

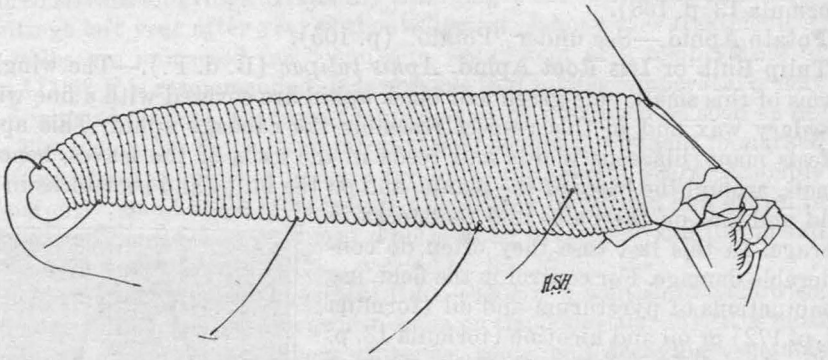


Fig. 37.—The blackberry mite, *Eriophyes essigi* Hassan, which causes the redberry disease of blackberries. (Very greatly enlarged.) (After Hassan.)

remain red, hard, and sour after the fruit is ripe. The mites spend the winter in the buds and attack the drupelets shortly after the flowers open. Spray with 5 gallons of lime-sulfur solution or 3 to 4 gallons of commercial winter oil emulsion per 100 gallons of water during the fall or dormant season when the leaf buds are just opening in the spring.

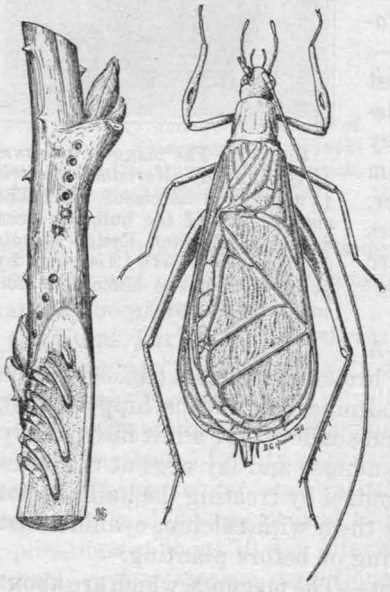


Fig. 38.—The snowy tree cricket, *Oecanthus niveus* (DeG.): egg punctures and exposed eggs in a raspberry stem, and adult male. (Greatly enlarged.) (From Bul. 505.)

Common Red Spider, *Tetranychus althaeae* (Van Hanst.), **Two-spotted Mite,** *T. bimaculatus* Harvey, **and the Pacific Mite,** *T. pacificus* McG.—These red spiders become serious on all bush fruits in June or July. They cause the leaves to turn brown and fall off. Spray with 1½ per cent summer oil and a spreader when damage is first noticed. Preferably follow with a second application about 10 days later. Caution: avoid emulsions which contain a strong odor because of possible effects on the fruit flavor.

Snowy Tree Cricket, *Oecanthus niveus* (DeG.).—This is a large, pale-green, delicate insect which feeds on the buds and flowers and may completely destroy the second crop. The eggs are inserted in rows, into the raspberry canes (fig. 38); this causes some breaking when the canes are loaded with fruit. The eggs hatch in the

spring, and the young crickets, because of their small size, do no damage to the first crop. Dust with 1 per cent rotenone dust at 75 pounds per acre in the intercrop period, about July.[16] If rotenone is not available, either sodium fluosilicate 70 per cent mixed with talc, or a cryolite dust (formula 6, p. 161) may be used until the fruit begins to set.

Rose Scale, *Aulacaspis rosae* (Bouché).—This is a small white scale (fig. 131, p. 110), often found in great numbers on the canes of blackberries, loganberries, and raspberries, where it produces a cottony appearance. Spray in winter with 4 per cent commercial oil emulsions, with 3½ per cent emulsive oils or 3½ per cent tank-mix oil spray. Prune out old canes every year, because infestation spreads from them. The scale is serious only where pruning is not practiced every year. When 2 per cent lime-sulfur is used as a fungicide, it gives some control of this scale also.

Glacial Whitefly, *Trialeurodes glacialis* (Bemis).—The immature forms are disklike, 1 mm in diameter, semitransparent, with wax rods extending from the sides and back of the body. The adults are minute whiteflies, which may occur with the immature forms in great numbers on the undersides of blackberry leaves. For control, spray with pyrethrum and oil (formula 18, p. 172) or oil and nicotine extracts (formula 13, p. 168) several times at weekly intervals.

Raspberry Root Borer, *Bembecia marginata* (Harris).—The larvae are white worms, identical in appearance with the strawberry crown borer, but larger, being about 1 inch long when mature. They attack the plants in the same manner as the strawberry crown borer and control measures are the same. See "Strawberry Crownborer" under "Strawberry" (p. 118).

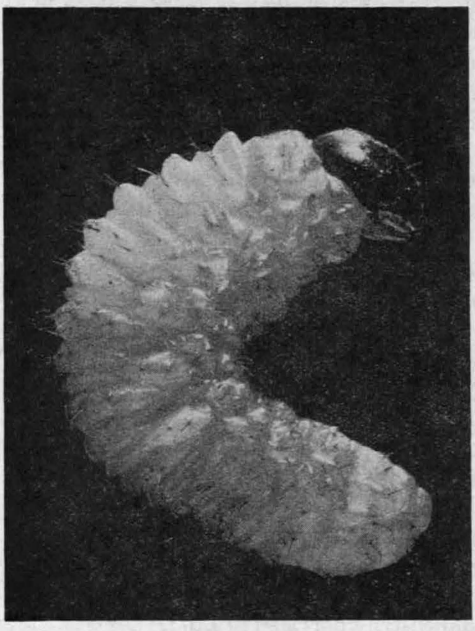
Strawberry Crownborer.—See under "Strawberry" (p. 120).

Strawberry Rootworm.—See under "Strawberry" (p. 120).

Black Vine Weevil, *Brachyrhinus sulcatus* (Fab.) **and the Rough Strawberry Weevil,** *Brachyrhinus rugosostriatus* (Goeze).—The adult of the black vine weevil (fig. 39) is black with small yellow tufts of hair on the back and is ⅝ inch long; the larva is a white, crescent-shaped, legless grub with a brown head, about ⅝ inch long when mature. The rough strawberry weevil is similar to the former but smaller and brown in color. The adults feed upon the leaves, and the larvae do great damage to the roots of blackberries, raspberries, strawberries, and a number of ornamentals. Best results are achieved with proprietary dried-apple-pulp baits. These should be applied at the rate of 75 pounds per acre when the beetles emerge from the ground, usually in May. Some control can be obtained by the use of baits as given in formula 27 (p. 179) or formula 28 (p. 179).

Raspberry Horntail, *Hartigia cressoni* (Kirby).—The white larvae (fig. 40) have a sharp spine on the tip of the body; they are shaped somewhat like the letter "S" and when mature are nearly 1 inch long. They first attack the tender tips of the new canes of raspberries, and after girdling them and causing wilting, they work down the pith to the roots, where they spend the winter. To control, cut off the young tips as soon as wilting is noticed so as to kill the

[16] See: Smith, Leslie M. The snowy tree cricket and other insects injurious to raspberries. California Agr. Exp. Sta. Bul. 505:1–38. 1930. (This bulletin is out of print but may be consulted in many city and county libraries in California.)



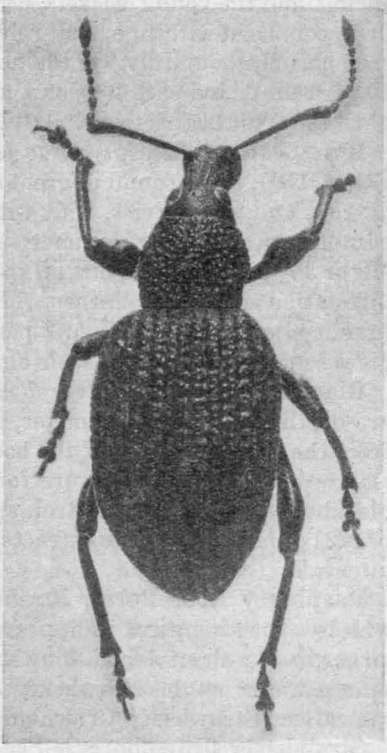


Fig. 39.—The larva and adult of the black vine weevil, *Brachyrhinus sulcatus* (Fab.). The adults feed on the tops and the larvae on the roots of many plants. (Greatly enlarged.) (From Bul. 505.)

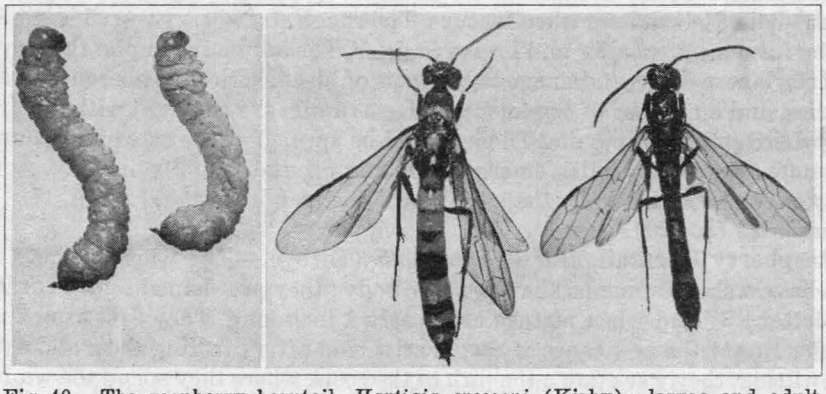


Fig. 40.—The raspberry horntail, *Hartigia cressoni* (Kirby): larvae and adult female and male. (About three times natural size.)

larvae before they reach the roots. Remove all dead canes in winter, using care to dig out the borers at that time.

Raspberry Leaf Sawfly, *Priophorus rubivorus* Rohwer.—The smooth, naked, pale-green larvae with a dark brown stripe down the back occasionally occur in great numbers feeding on the lower surfaces of the leaves of raspberry in June. Dust with ½ per cent commercial rotenone dust, or if possible wait until time to dust for snowy tree cricket, to control both insects with one application. If rotenone is not available, commercial sodium fluosilicate or cryolite dust may be used up until the fruit sets.

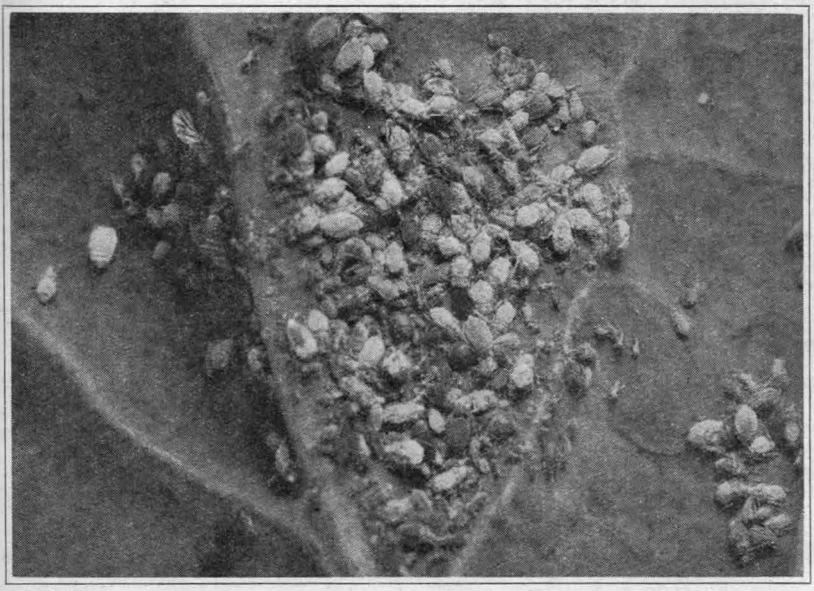


Fig. 41.—A colony of the cabbage aphid, *Brevicoryne brassicae* (Linn.), on an exposed leaf. (Enlarged.)

Raspberry Cane Maggot, *Pegomya rubivora* (Coq.).—Adult flies are gray, slender and about the size of the common housefly. They emerge in the spring and lay their eggs on the tips of the raspberry canes. The larvae bore around the stem in the cambium, then burrow down the pith channel. The cane is girdled and the tip wilts. To control, remove and burn wilted canes as soon as noticed, taking care to cut the cane below the maggot.

CABBAGE (BROCCOLI, BRUSSELS SPROUTS, CAULIFLOWER, KALE, MUSTARD, TURNIP, RADISH, STOCK)

Cabbage Aphid, *Brevicoryne brassicae* (Linn.), **and Turnip Aphid,** *Rhopalosiphum pseudobrassicae* (Davis).—The cabbage aphid (fig. 41) is small, green and entirely covered with fine whitish powdery wax. The turnip aphid is very similar to the cabbage aphid, but with much less frosty wax covering. Both are controlled by liberal and repeated applications of oil and nicotine spray (formula 13, p. 168, with summer oil), of nicotine and soap spray (formula 16, p. 171) or pyrethrum and oil spray (formula 18, p. 172). Thor-

ough application is necessary, beginning with the initial infestations. Dusting with a 4 per cent nicotine dust at the rate of 15 to 25 pounds per acre, done as soon as the aphids appear, and then repeated, will give control.

Harlequin Cabbage Bug, *Murgantia histrionica* (Hahn).—The adults, oval in shape, about ⅜ inch long, and black with orange or reddish markings (fig. 42), hibernate and then lay small clusters of barrel-shaped eggs with alternate white and black bands. Three or four generations develop at 1- or 2-month intervals according to temperature. Injury results from the sucking of plant juices, causing wilting and eventual curling and death of the plants.

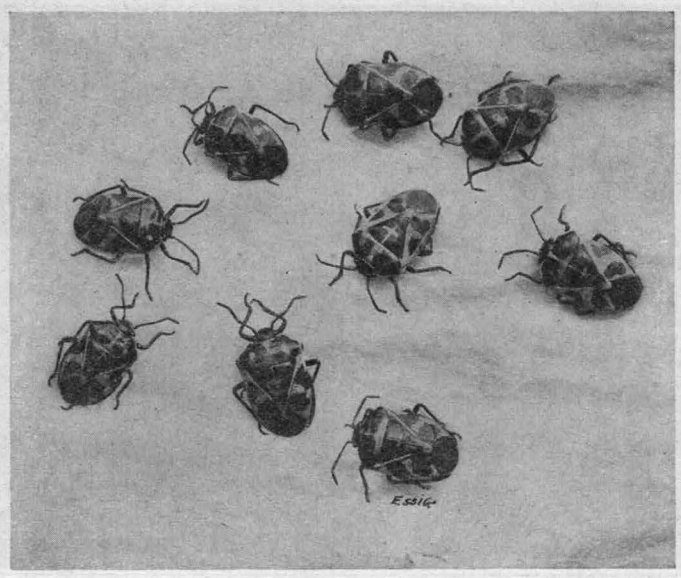


Fig. 42.—The harlequin cabbage bug, *Murgantia histrionica* (Hahn), a beautiful black bug marked with white, yellow, and red. (Slightly enlarged.)

Control is difficult but may be accomplished by clean cultivation to cut down overwintering adults and by trap crops such as mustard, turnip, or radish to concentrate the bugs after harvest, at which time they may be destroyed by spraying with kerosene or by burning. During the growing season, contact sprays, such as organic thiocyanate (Lethane), commercial 2 per cent pyrethrum extract, or 40 per cent nicotine sulfate at a dilution of 1 part to 600 parts of water plus a 2 per cent summer-type oil, are moderately effective if the bugs are actually wet by the spray.

Armyworms and Cutworms.—See page 144. Scatter poison bran (formula 27 or 31, p. 179 and 180) broadcast over the ground and plants in the evening.

Cabbage Looper, *Autographa brassicae* (Riley).—The caterpillars are large, green with longitudinal white stripes, 1½ inches long when mature, and move in looper fashion. Cocoons occur on the plants or litter above ground and are composed of a silken network. The adult is a moth. Control as for cabbage worm.

Corn Earworm, or Tomato Fruitworm, *Heliothis armigera* (Hbn.).—Occasional infestations of these caterpillars occur on broccoli and other cruciferous plants. When the plants are small, before heads appear, undiluted calcium arsenate or 50 per cent cryolite dust, 25 pounds per acre, offers some control. See under "Corn" (p. 56) and "Tomato" (p. 123).

Diamondback Moth, *Plutella maculipennis* (Curtis).—This is the smallest of the caterpillars on cabbages and related plants, about ⅓ inch long, tapered to both ends and very active. The cocoons are composed of a delicate netted silken material (fig. 43) characteristic of this moth. Adults are easily distinguished when they are at rest by an irregular stripe along the upper border of the wing which forms three diamond-shaped markings. Control as for cabbage worm.

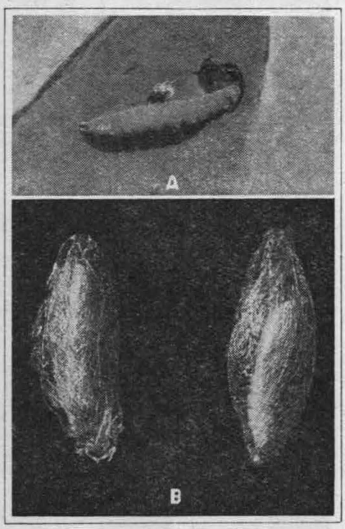


Fig. 43.—The diamondback moth, *Plutella maculipennis* (Curtis): *A*, feeding larva; *B*, chrysalids within the thin silken cocoons. (Both enlarged.)

Cabbage Worm, *Pieris rapae* (Linn.).—A small green velvety worm, 1 inch long when mature, feeds upon the leaves and destroys the heads of cabbage, and defoliates related plants. The adults are the white cabbage butterflies with dark spots on the front wings (fig. 44). On the small plants before heads appear, a 50 per cent cryolite dust can be used. As soon as the heads form, dust with a 1 per cent rotenone dust or a pyrethrum dust containing 0.1 per cent pyrethrins. These materials can also be used as sprays. The amounts of dusts needed will vary from 15 pounds to 35 pounds per acre according to the method of application and the size of the plants.

Vegetable Weevil.—See under "Carrot" (p. 42).

Cabbage Maggot, *Chortophila brassicae* (Bouché).—The small white maggots, ¼ inch long, are found tunneling the stems (fig. 45) and roots, which are often completely destroyed by them. The insect attacks not only cabbage but also radishes, turnips, cauliflower, and other related plants. The most effective means of control is to treat the base of the plants and adjoining soil with a repellent consisting of either mercuric chloride (corrosive sublimate) at the rate of 1 ounce to from 8 to 10 gallons of water (formula 8, p. 162) or mercurous chloride (calomel) at the rate of 3 or 4 ounces to 10 gallons of water. Add a small amount of a sticking agent such as gum arabic. The solutions are used at the rate of 1 cup (½ pint) to each plant, applied around the base of the plant. The material can be

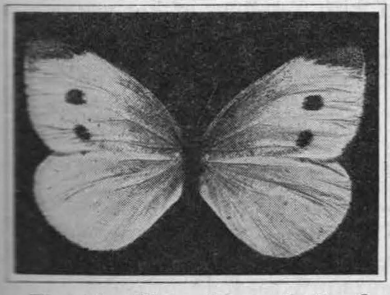


Fig. 44.—The cabbage butterfly, *Pieris rapae* (Linn.), adult of the cabbage worm.

applied with a watering can suitably regulated. Eastern investigators have found that a dust consisting of 1 part of mercurous chloride to 25 parts of an inert diluent such as talc, applied at the rate of 75 pounds per acre 4 to 5 days after transplanting, followed by several additional applications at 10-day intervals, gives adequate control. Three applications are usually necessary.

Fig. 45.—The cabbage maggot, *Chortophila brassicae* (Bouché), infesting the stems of young cabbage plants; the nature of injury is shown.

Clean up all refuse in the fall; and plow and cultivate thoroughly during fall, winter, and spring, before transplanting, to expose and kill overwintering pupae in the soil. Seedbeds can be protected by screening with a fine-mesh cloth gauze.

CAMELLIA

Camellia Rust Mite, *Calacarus adornatus* (Keifer).—This microscopic, elongated mite feeds on both surfaces of the leaves of camellia and snowball and causes a browning effect and marking of the leaves. For control use a 1 per cent light summer-type oil spray or the like.

Thrips.—Various species of flower thrips attack the opening buds and cause a deforming and browning of the petals. A measure of control can be obtained by spraying frequently with nicotine sulfate, rotenone, or pyrethrum as recommended for greenhouse thrips (p. 21).

Black Citrus Aphid, *Toxoptera aurantii* (B. d. F.).—A black or maroon (young) species of aphid (fig. 46) infests the tender tips of camellias. To control, spray with nicotine and soap (formula 16, p. 171) or pyrethrum and oil (formula 18, p. 172) or 1 pound of powdered soap mixed with 5 gallons of hot water but applied cold.

Scale Insects.—Various species of scales having minute, circular, grayish scales, or shells, attack camellia. They may be controlled by the application of highly refined oil sprays as recommended under "Citrus Fruits" (p. 50).

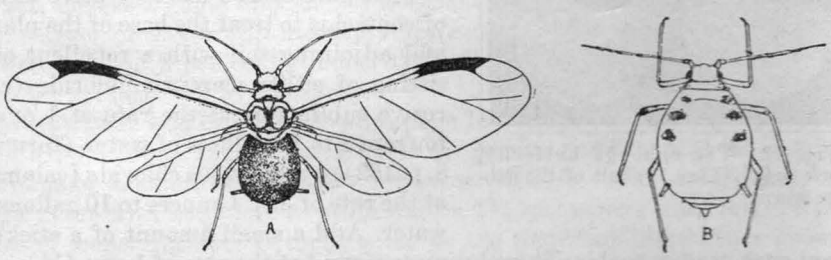


Fig. 46.—Winged and wingless forms of the black citrus aphid, *Toxoptera aurantii* (B. d. F.), which frequently infests the tender shoots of the camellia.

CANTALOUPE

(See "Melons," p. 83)

CARNATION

Carnation Bud-Rot Mite, or Grass Mite, *Pediculopsis graminum* Reuter.—The mature forms are relatively large, white, egg-shaped mites living in considerable numbers in carnation buds infected with the carnation bud-rot, caused by the fungus *Sporotrichium poae* Peck. The young very minute mites spread the fungus from plant to plant and appear to confine their feeding to diseased buds. This mite occurs chiefly in greenhouses. Control of the mite and fungus consists in picking and burning all buds showing evidence of infestation.

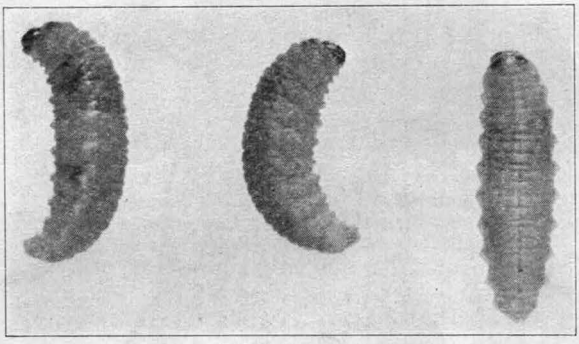


Fig. 47.—Larvae of the vegetable weevil, *Listroderes obliquus* Klug, about four times natural size. (After Lovell.)

Two-spotted Mite.—See under "Beans" (p. 23).

Thrips.—Various species of flower thrips attack the opening buds and cause a deforming and browning of the petals. A measure of control can be obtained by spraying frequently with nicotine sulfate, rotenone, or pyrethrum in combination with oil. See formulas 13, 16, or 18 (p. 168, p. 171, and p. 172).

Green Peach Aphid.—See under "Bulbs" (p. 32).

Leaf Roller Moths; Apple Skinworm, *Tortrix franciscana* (Walsm.), **Carnation Moth,** *Platynota stultana* Walsm., **and Oblique-banded Leaf Roller,** *Archips rosaceana* (Harris).—These three insects have small greenish caterpillars, about 1 inch long, which web the leaves into small clusters or nests, within which the caterpillars feed and rest. When disturbed they wriggle violently backwards and retreat to the ground on a silken thread. On carnations they often destroy the buds as well as the leaves and may be rather injurious in greenhouses. Pupation occurs in the injured buds or rolled leaves, or in debris about the beds or on the ground. The moths are variously colored in shades of brown, light tan, and dusky. They rest mostly during the day and become active just at nightfall. Control consists in hand-picking the larvae and in the application of calcium arsenate dust, or a spray of 4 pounds of lead arsenate per 100 gallons of water, or natural cryolite, 6 pounds per 100 gallons of water.

CARROT

Vegetable Weevil, *Listroderes obliquus* Klug.[17]—This insect is a brown or buff-colored snout beetle (fig. 48) ⅜ inch long and with two rather prominent tubercles near the posterior end of the wing covers. The larvae (fig. 47) are legless, green grubs ½ inch long when mature. The larvae and adults feed on the foliage of carrots and turnips and on the tops of a number of other vege-

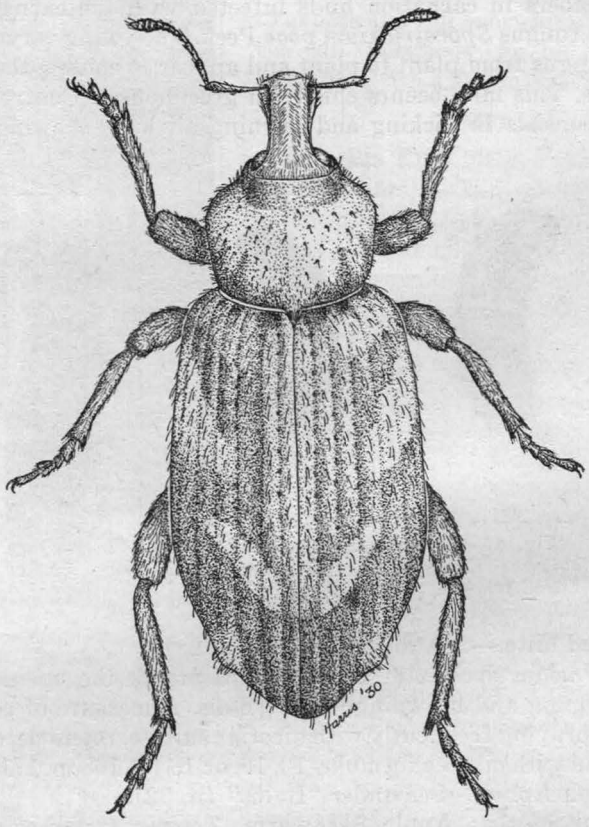


Fig. 48.—The vegetable weevil, *Listroderes obliquus* Klug, adult (greatly enlarged). (After Essig, *A History of Entomology*, by permission of the Macmillan Co., publishers.)

tables, and the larvae may also feed on the roots, particularly of turnips and carrots, during the winter and spring months. Dusting with sodium fluosilicate dust 70 per cent to 80 per cent strength, at the rate of 30 to 40 pounds per acre if foliage is dense, and at the rate of 15 to 25 pounds if the foliage is thin, or 33 to 50 per cent cryolite dusts as soon as the larvae begin to appear in the winter and spring, will give satisfactory control. In such cases the tops should not be used for food, either for humans or domesticated animals, for fear of poisoning.

[17] Lovell, Oliver H. The vegetable weevil, *Listroderes obliquus*. California Agr. Exp. Sta. Bul. 546:1–19. 1932. (This bulletin is out of print but may be consulted in many city and county libraries in California.)

Wireworms.—See page 149. The effect on carrots is shown in figure 49.

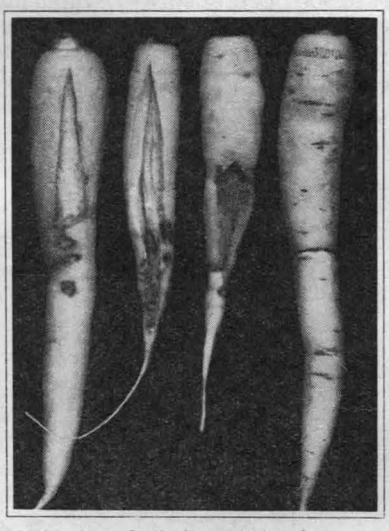


Fig. 49.—Splitting of the three carrots on the left due to the feeding of wireworms; the constriction of the one on the right is due to bacterial blight. (Photograph by W. H. Lange.)

CASABA

(See "Melons," p. 83)

CAULIFLOWER

(See "Cabbage," p. 37)

CELERY

Root-Knot Nematode, *Heterodera marioni* (Cornu).—The problem of root-knot nematode on celery is discussed by Smith as follows:

> The roots attacked by this pest are covered with galls or swellings and the plants are stunted. This is the common garden nematode, ... which has a great variety of host plants.
>
> In places where celery is troubled with nematode, great care should be taken that the soil of the seedbed is free from anything which might introduce the pest. Infested fields should not be planted to celery or any other vegetable or susceptible host but may be used for summer-fallow winter cereals for one or more years. The soil must be kept clean of all plant growth in summer, to starve out the nematode. [See p. 136.][18]

Aphids.—At least eleven species of aphids are known to be capable of transmitting the disease known as western celery mosaic in California. Of these the rusty-banded aphid, *Aphis ferruginea-striata* Essig; the cotton or melon aphid, *Aphis gossypii* Glover (see under "Melon," p. 84); the lily aphid, *Myzus circumflexus* (Buck.) (see under "Lily," p. 83); the foxglove aphid, *Myzus convolvuli* (Kalt.); the green peach aphid, *Myzus persicae* (Sulzer) (see under "Bulbs," p. 33); and the honeysuckle aphid, *Rhopalosiphum conii*

[18] From: Smith, Ralph E. Diseases of truck crops. California Agr. Ext. Cir. 119:33. 1940.

(Dvd.), are the commonest species.[19] These aphids may be controlled with nicotine spray (1 part to 800 parts of spray), which may be combined with the bordeaux sprays used for control of blight.

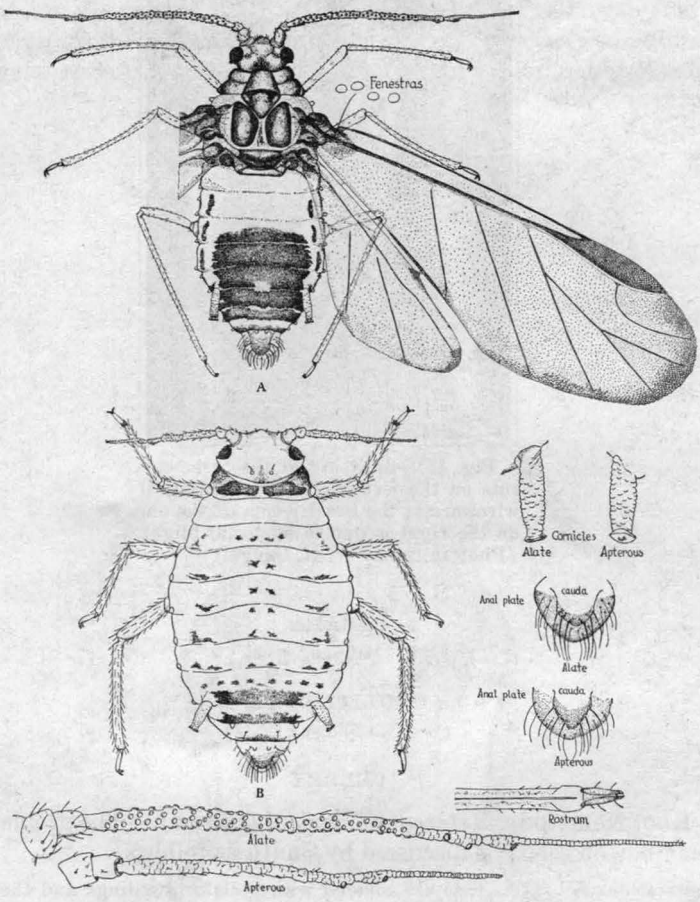


Fig. 50.—The rusty-banded aphid, *Aphis ferruginea-striata* Essig: *A*, adult winged female; *B*, adult wingless female. Other parts are labeled. (All greatly enlarged.) (From *Hilgardia* Vol. 11, No. 9.)

Smith describes western celery mosaic and discusses its control as follows:

The young leaflets of plants attacked by this virus disease are mottled with green and yellow areas [fig. 51] and in advanced stages become narrow, twisted, and cupped. The plants are stunted, the central leafstalks being shortened and the outer ones assuming a horizontal position. The disease is most prevalent during the summer months and is spread by aphids from plant to plant. No wild host plants are known, but carrots and celeriac are susceptible.

Several other mosaiclike diseases of celery are distinguished in California, including those called "calico," "yellow spot," and "ring spot," as well as aster yellows . . . and spotted wilt.

[19] Essig, E. O. Aphids feeding on celery in California. Hilgardia Vol. 11 (No. 9):459–492. 1938.

. . . These are much less important than western celery mosaic, which is a serious disease in most celery-growing districts of the state.

Spraying to control aphids may help to prevent the spread of mosaic. In one part of the state, the control of mosaic has been attempted by the legal establishment of a "celery-free period" of 3 months, during which time no celery plants are allowed to exist in the district.[20] Such a period is expected to eliminate the principal source of mosaic infection: growing celery plants.[21]

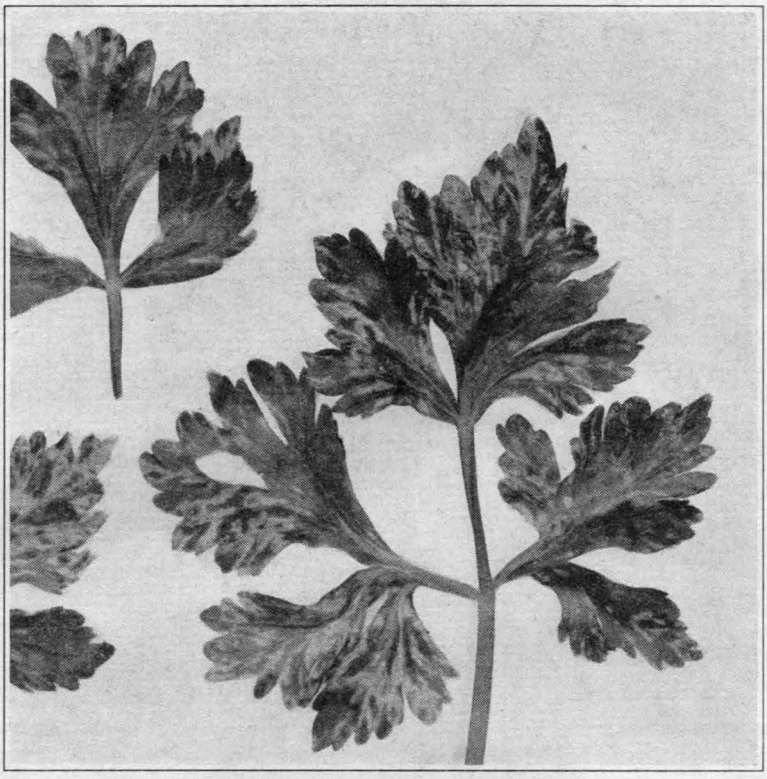


Fig. 51.—Celery leaves showing the mottled effects of western celery mosaic. (From Ext. Cir. 119.)

Western Parsley Caterpillar, *Papilio zelicaon* Lucas.—The caterpillars are beautifully marked, green, black, and orange, and feed upon the leaves. For control, hand-pick, dust with pyrethrum (preferred), or commercial rotenone dusts. Spraying celery with poisons is a dangerous procedure and should not be done without the advice of experts.

Celery or Greenhouse Leaftier, *Phlyctaenia ferrugalis* Hbn.—The caterpillars are pale green with white or yellow stripes and are characterized

[20] See: Milbrath, D. G., and Harold J. Ryan. A method of control of western celery mosaic. California State Dept. Agr. Bul. 27:290–95. 1938.

[21] From: Smith, Ralph E. Diseases of truck crops. California Agr. Ext. Cir. 119:31–33. 1940.

For a technical discussion of this disease, see: Severin, Henry H. P., and Julius H. Freitag. Western celery mosaic. *Hilgardia* Vol. 11 (No. 9) :493–558. 9 figs. 8 pls. 1938.

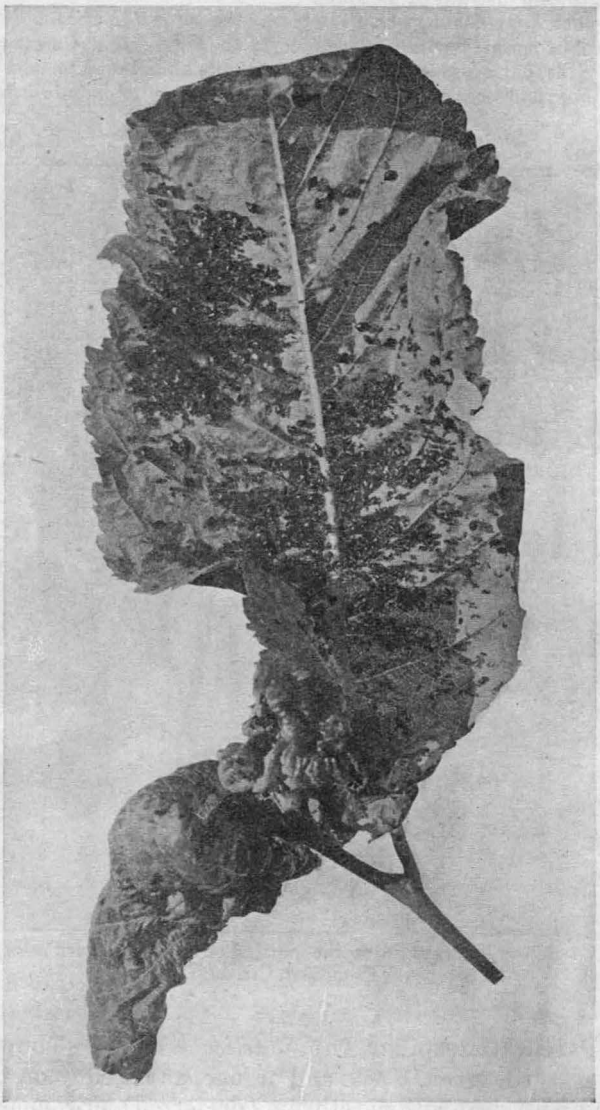


Fig. 52.—The black cherry aphid, *Myzus cerasi* (Fab.): a colony in a curled cherry leaf. In this condition it is beyond control for the season.

by two black spots on the sides of the first thoracic segment. The disk-shaped eggs are laid singly or overlapping in groups. The adults are pale yellowish red. Damage is caused by the caterpillars, which web and eat the foliage. Pyrethrum sprays (formula 16, p. 171) or commercial pyrethrum dusts, if thoroughly applied, offer satisfactory control.

CHERRY

Pear Thrips.—See under "Pear" (p. 99).

Black Cherry Aphid, *Myzus cerasi* (Fab.).—This shiny black aphid with long honey tubes appears in spring and early summer and causes severe curling of the leaves (fig. 52). Spray with nicotine and soap (formula 16, p. 171) or dust thoroughly with 2 per cent nicotine dust (see p. 171) as soon as aphids appear and before the leaves curl.

Cankerworms.—See page 148.

Pacific Peach Tree Borer.—See under "Peach and Nectarine" (p. 97).

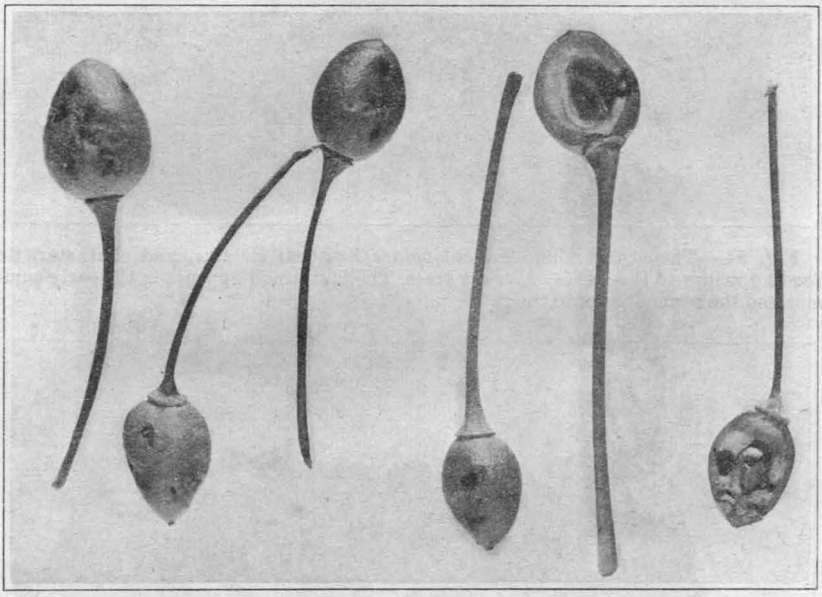


Fig. 53.—Work of the larvae of the cherry fruit sawfly on young cherries. The soft seed is completely devoured and the fruit ruined.

Red-humped Caterpillar.—See under "Plum and Prune" (p. 104).

Tent Caterpillars.—See page 147.

Cherry Fruit Sawfly, *Hoplocampa cookei* (Clarke).—The small white larvae work within the partly developed fruits of the cherry (fig. 53) and plum and are at times responsible for much damage. Their presence is indicated by the dropping of fruit and by the small round exit holes in fruits which are hardly half-grown. The best treatment is the application of basic lead arsenate (formula 2, p. 156) just when the petals are opening.

Cherry or Pear Slug, *Eriocampoides limacina* Retzius.—This name applies to the small dark green or blackish sluglike larvae (fig. 54), which are nearly ½ inch long and which feed upon the leaves in great numbers, almost defoliating the trees in some years. Because of their slimy covering, they are readily killed by the application of various dusts, such as finely ground hydrated lime, ashes, and road dusts, but are best controlled by the applications of 0.8

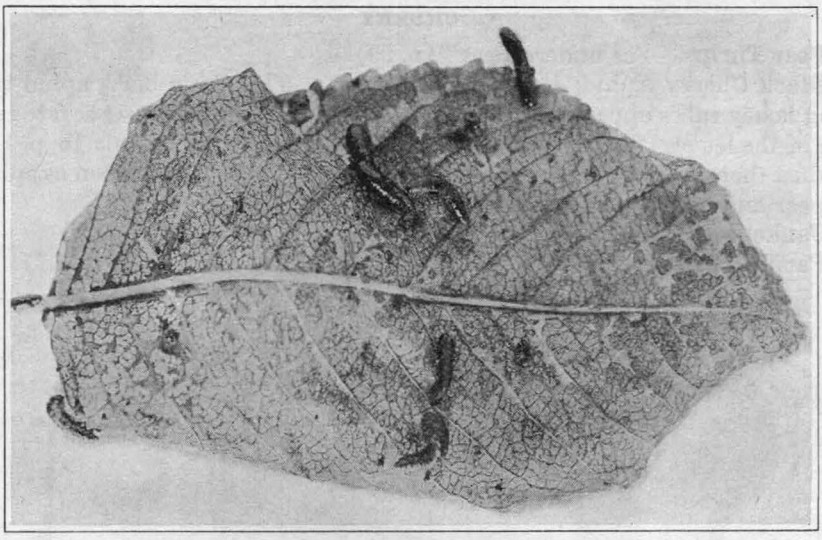


Fig. 54.—The cherry slug, *Eriocampoides limacina* Retzius, and characteristic feeding injury to the leaves of cherry trees. The first brood appears in the early summer and the second brood in the fall.

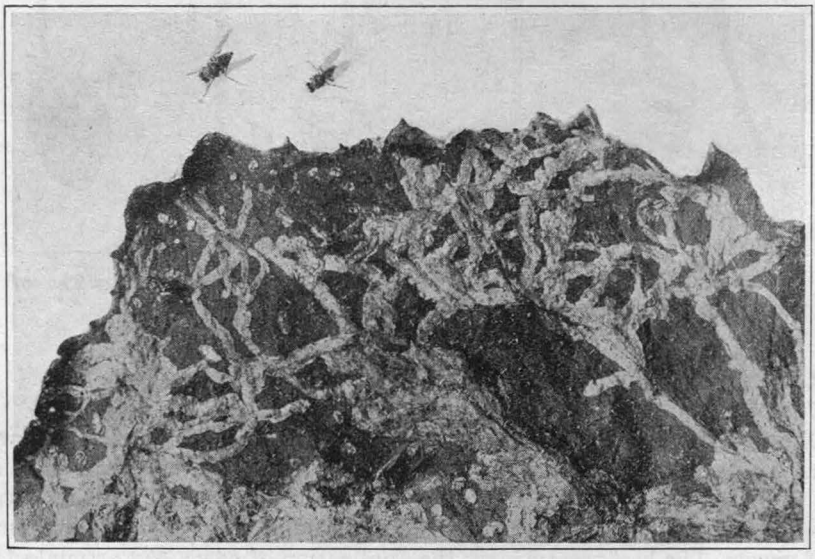


Fig. 55.—Adults of the chrysanthemum leaf miner, *Phytomyza chrysanthemi* Kow., and mines of the larvae in the leaf.

per cent to 2.0 per cent nicotine dust (see p. 172). The regular basic lead arsenate sprays (formula 2, p. 156) are also good.

Poison sprays should not be applied from the time the fruit is half-grown until after it is harvested. Usually the most opportune time is either in early spring or after harvest.

CHRYSANTHEMUM

Two-spotted Mite.—See under "Bean" (p. 23).

Aphids: Chrysanthemum Aphid, *Macrosiphum sanborni* Gill., **and Leaf Curl Plum Aphid,** *Aphis helichrysi* Kalt.—The first is a large, shiny black species and the second a very small yellowish or pale-green species, both feed-

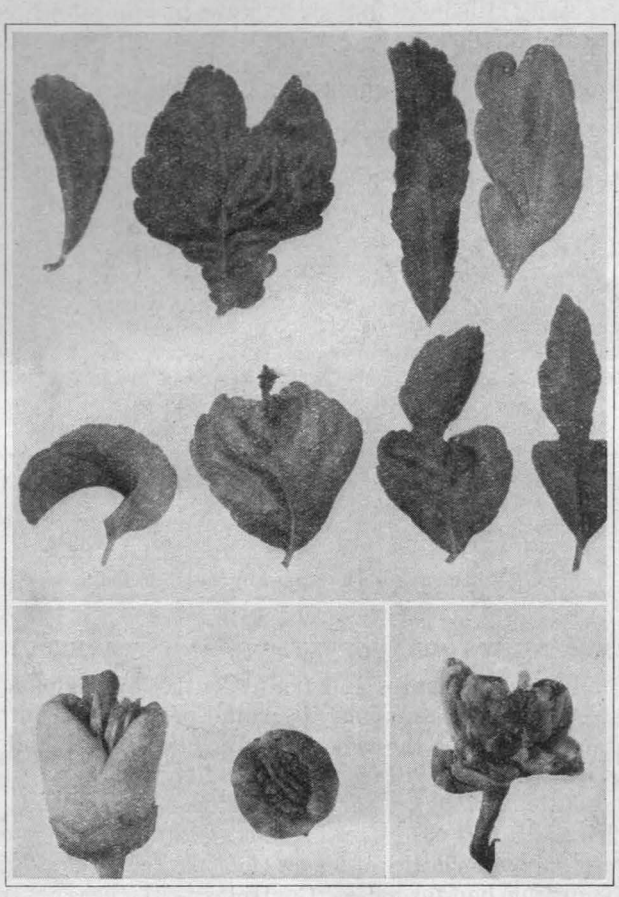


Fig. 56.—Deformed leaves, buds, and blossom of lemon caused by the citrus bud mite.

ing mostly on the young shoots and the tips of the older branches and the buds. They often cause deformity of the leaves and buds. For both, dust with 2 per cent nicotine dust or spray with a solution of 1 pound of powdered soap to 5 gallons of water or with oil and nicotine (formula 13, p. 168) or with pyrethrum and oil (formula 18, p. 172).

Chrysanthemum Gall Midge, *Diarthronomyia hypogaea* (F. Löw).—The small yellowish or white larvae cause numerous pointed galls on the leaves and stems and seriously injure the terminal buds. Great numbers of minute, slender, red eggs are laid on the plants in the spring and early summer, and

these may be readily killed by repeated applications of nicotine and soap (formula 16, p. 171). Trim the plants to the ground in the spring to eliminate holdover forms.

Chrysanthemum Leaf Miner, *Phytomyza chrysanthemi* Kow.—The injury due to this insect consists in numerous mines on the upper side of the leaves just under the epidermis (fig. 55). These are made by the small whitish maggots, which are easily killed within their burrows by applying 1 part of 40 per cent nicotine sulfate to 600 parts of water.

CINERARIA

Chrysanthemum Leaf Miner.—See under "Chrysanthemum" (p. 50).

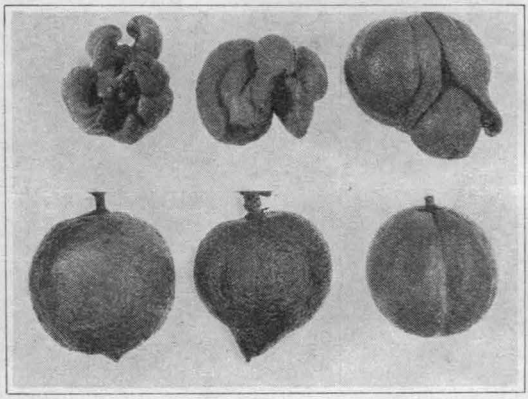


Fig. 57.—Lemon fruits deformed by the citrus bud mite.

CITRUS FRUITS (ORANGE, LEMON, AND GRAPEFRUIT)[22]

Snails.—Snails feed on leaves and fruit. Control by use of poisoned bait (formula 29, p. 180; note discussion), ½ pound per tree, in winter or spring. Slugs sometimes cause much the same sort of injury as snails and may be controlled in the same way. See "Slugs and Snails" (p. 138).

Citrus Bud Mite, *Eriophyes sheldoni* Ewing.—This mite is very small, invisible without a lens. It occurs in the buds and under the buttons of fruits. Its feeding results in deformities of leaves (fig. 56), fruit (fig. 57), and flowers (fig. 56), and multiple bud formation. Control with 1⅔ per cent light-medium or medium summer-type oil sprays or 2 per cent lime-sulfur solution plus 4 pounds of sulfur per 100 gallons of spray.

Citrus Rust Mite or Silver Mite, *Phyllocoptruta oleivorus* (Ashm.).—This is a microscopic, yellowish, wormlike mite, occurring chiefly in limited areas in San Diego County and causing a silvery appearance of lemons. It is controlled by sulfur dust.

[22] For further details see:

Quayle, H. J. Biology and control of citrus insects and mites. California Agr. Exp. Sta. Bul. 542:1–87. 1932. (This bulletin is out of print but may be consulted in many city and county libraries in California.)

Quayle, H. J. Control of citrus insects and mites. California Agr. Ext. Cir. 123:1–31. 1941.

Quayle, H. J. Insects of citrus and other subtropical fruits. 583 p. 375 figs. Comstock Pub. Co., Ithaca, N. Y. 1938.

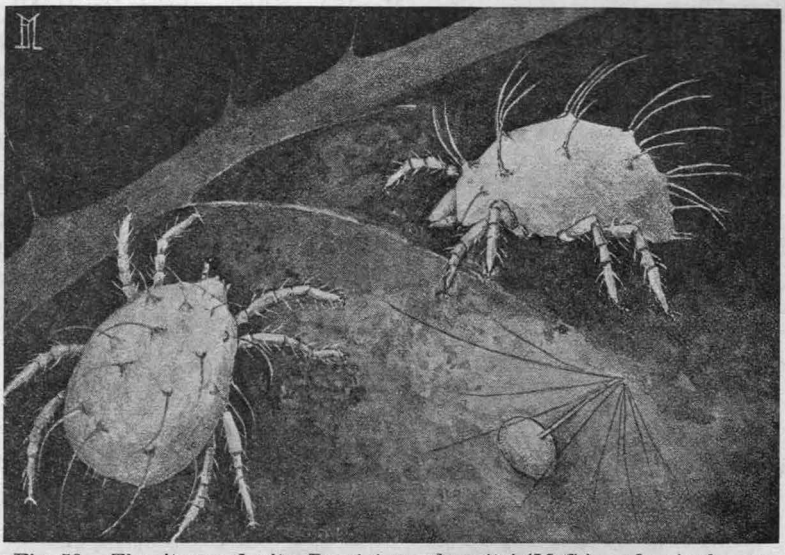


Fig. 58.—The citrus red mite, *Paratetranychus citri* (McG.), and a single egg. (Greatly enlarged.) (After Quayle.)

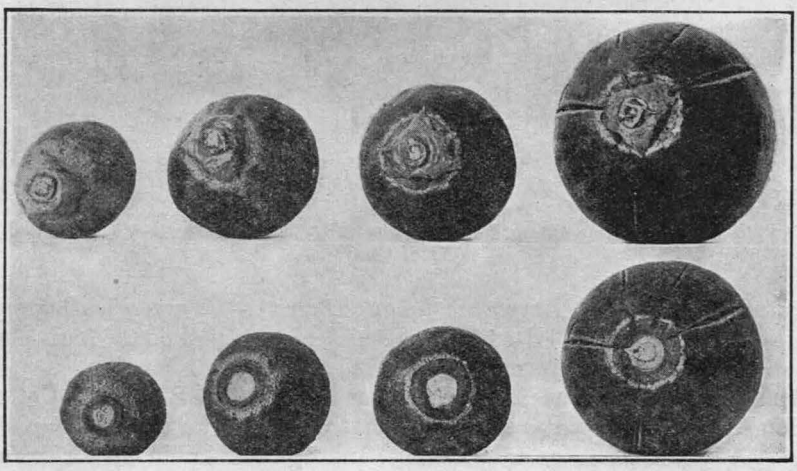


Fig. 59.—Characteristic scarred rings on oranges caused by the feeding of the citrus thrips.

Citrus Red Mite, *Paratetranychus citri* (McG.).—The commonest injurious mite or red spider of citrus, this species (fig. 58) causes leaves and fruit to become pale-colored. For control, use oil spray or commercial dinitro-*o*-cyclohexylphenol dust; preferably two applications of the latter with an interval of 10 to 14 days.

Six-spotted Mite, *Tetranychus sexmaculatus* Riley.—This is a pale-colored mite that feeds in definite areas on the underside of the leaves. For control use oil sprays or dinitro-*o*-cyclohexylphenol dust.

Citrus Thrips, *Scirtothrips citri* (Moult.).—Citrus thrips is a small, pale-yellow, active insect that attacks younger leaves and fruit (fig. 59). The leaves become misshapen and leathery, and there is a scarred ring around the button of the fruit. For control, use tartar-emetic spray (formula 21 or 22, p. 176) or sulfur dust. In case of resistance to tartar emetic, consult the local farm advisor or the Agricultural Experiment Station.

Greenhouse Thrips, *Heliothrips haemorrhoidalis* (Bouché).—A darker-colored and larger species than the citrus thrips, greenhouse thrips attacks mature fruit and causes a pale color and a roughened texture. For control, use pyrethrum or pyrethrum and oil spray (formula 18, p. 172) or oil and nicotine spray (formula 13, p. 168).

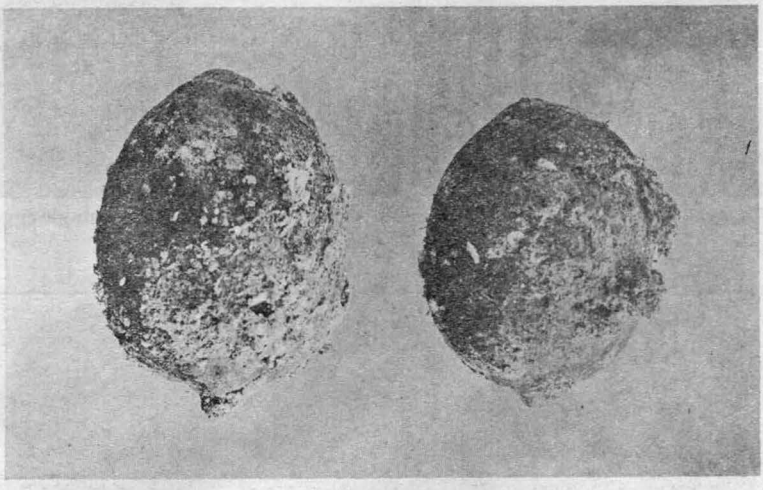


Fig. 60.—Citrus mealybug, *Pseudococcus citri* (Risso), on fruits of the lemon. (After Quayle.)

Potato Leafhopper, *Empoasca fabae* (Harris).—A green leafhopper migrates to citrus in the fall. Its feeding results in gray spots on the fruit. Control with whitewash spray (formula 24, p. 178).

Aphids: Black Citrus Aphid, *Toxoptera aurantii* (B. d. F.), **Cotton or Melon Aphid,** *Aphis gossypii* Glover, **Potato Aphid,** *Macrosiphum euphorbiae* (Thos.) (=*gei* Koch=*solanifolii* Ashm.), **and Spiraea Aphid,** *Aphis spiraecola* Patch.—All these aphids feed upon the foliage and especially the tender tips. Nursery stock and buds are sometimes injured by them. Many of the treatments for other insects will control these. Otherwise dust with nicotine dust or spray with nicotine sulfate (formula 17, p. 171).

Citrophilus Mealybug, *Pseudococcus fragilis* Brain (*P. gahani* Green), **Citrus Mealybug,** *P. citri* (Risso), **Long-tailed Mealybug,** *P. longispinus* (Targ.), **and Grape Mealybug,** *P. bakeri* Essig.—Mealybugs (figs. 60 and 119, p. 100) are scale insects with a mealy white covering that attack various parts of the tree. They are usually kept under control by insect enemies. When outbreaks occur, natural enemies may be secured from insectaries. It is important to control the Argentine ant (see p. 152).

Cottony-Cushion Scale, *Icerya purchasi* Mask.—This is a conspicuous white-ribbed cottony-covered scale (fig. 61). The body and legs are red, and the waxy covering of the immature forms is yellow. This scale is of historic interest and now rarely becomes injurious. It may be controlled by the use of the vedalia ladybird beetle, which may be procured from insectaries.

Fig. 61.—The cottony-cushion scale, *Icerya purchasi* Mask. (After Quayle.)

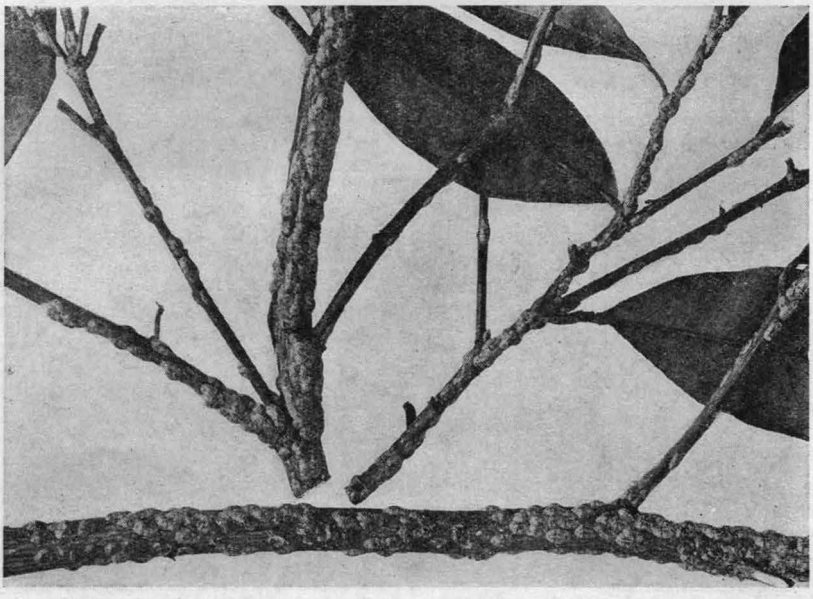


Fig. 62.—The citricola scale, *Coccus pseudomagnoliarum* (Kuw.), on orange twigs. (After Quayle.)

Citricola Scale, *Coccus pseudomagnoliarum* (Kuw.).—A gray, soft, unarmored scale that matures in the spring, the citricola scale (fig. 62) occurs on the smaller twigs. For control, use cyanide fumigation, oil sprays, or sulfur dust.

Black Scale, *Saissetia oleae* (Bern.).—The black scale (fig. 63) is a dark-brown or black, hemispherical-shaped, unarmored species that occurs chiefly on twigs and smaller branches. Control with cyanide fumigation or oil sprays.

Purple Scale, *Lepidosaphes beckii* (Newm.).—An elongated, curved, tapering, armored scale insect attacks leaves, fruit, and branches. Control with cyanide fumigation or oil sprays or both.

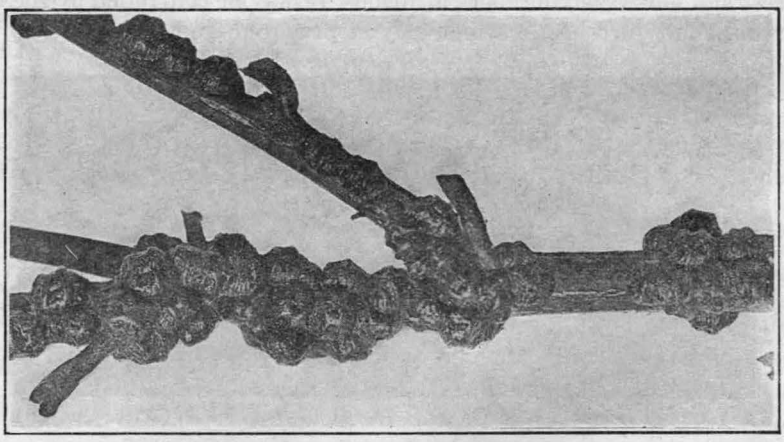


Fig. 63.—The black scale, *Saissetia oleae* (Bern.), a common pest of citrus, olives, oleander, pepper trees, and many other fruit and ornamental trees and shrubs.

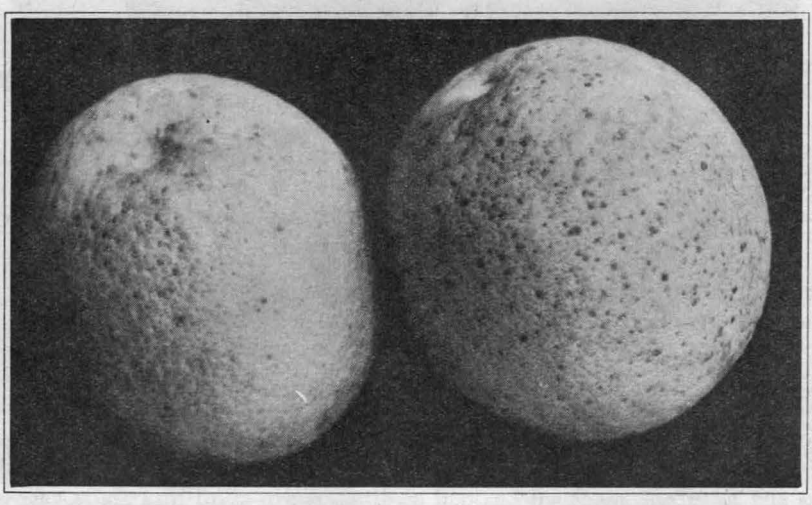


Fig. 64.—Red scale, *Aonidiella aurantii* (Mask.), on oranges. (Photograph by G. E. Woodhams.)

Red Scale, *Aonidiella aurantii* (Mask.).—A reddish-brown, circular, armored scale insect of pin-head size, this species (fig. 64) attacks all parts of the tree. Control with cyanide fumigation or oil sprays or both.

Yellow Scale, *Aonidiella citrina* (Coq.).—Similar to the red scale but yellow in color, this species is limited largely to the fruit and leaves. Control with cyanide fumigation or oil sprays or both.

Orange Tortrix, *Tortrix citrana* Fern.—The larva of this insect is a small caterpillar that bores into the rind of the fruit and causes the fruit to drop or to decay if the infested fruit is not culled out in the packing-house. For control spray or dust with cryolite (formula 5, p. 161, or formula 6, p. 161).

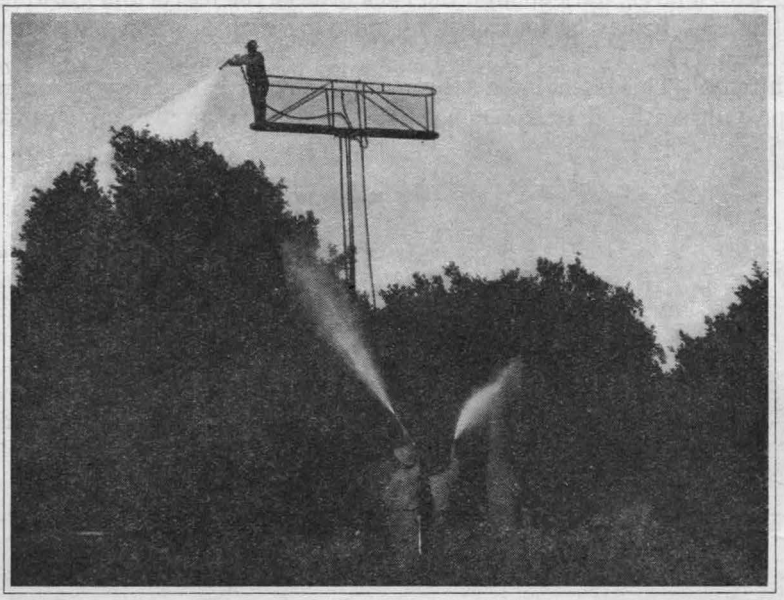


Fig. 65.—Spraying orange trees from the ground and from a tower. Spray guns are being used.

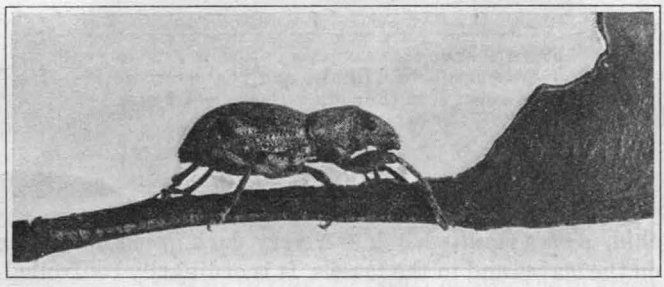


Fig. 66.—Fuller rose weevil, *Pantomorus godmani* (Crotch), adult and its work on lemon leaf. (About four times natural size.) The legless white larvae attack the roots of many rosaceous plants.

Fuller Rose Weevil, *Pantomorus godmani* (Crotch).—A gray beetle (fig. 66), 3/8 inch long, eats around edges of leaves and is most injurious on recently budded trees or interplants. Spray or dust with cryolite (formula 5, p. 161, or formula 6, p. 161) or use a barrier of cotton or sticky material on the trunk.

Argentine Ant, *Iridomyrmex humilis* Mayr.—This very small ant is associated with certain scale insects, mealybugs, and aphids, because it feeds on the honeydew given off by them. Where aid or dependence on control rests with

parasites, the ant interferes. It may be controlled with poison baits (see formula 33, p. 181).

COLUMBINE

Columbine Aphid, *Kakimia essigi* (Gill. & Palmer).—A green or pinkish aphid with a large, dark spot on the back attacks the leaves and growing tips of columbine. It may be controlled by spraying with nicotine and soap (formula 16, p. 171).

Whitefly.—This insect infests the underside of leaves and may be controlled by spraying with oil or rotenone. See: "Glacial Whitefly" under "Bean" (p. 26).

Fig. 67.—The corn earworm or tomato fruitworm, *Heliothis armigera* (Hbn.), and characteristic injury to sweet corn. For other stages, see figure 146 (p. 126).

CORN

Grasshoppers.—See page 142.

Corn Aphid, *Aphis maidis* Fitch.—A very dark green aphid is often very abundant on the leaves and in the tassels. It is ordinarily controlled by predators and parasites and rarely deserves attention.

Angoumois Grain Moth.—See under "Stored Cereals and Beans" (p. 114).

Armyworms and Cutworms.—See page 144.

Granary Weevil and Rice Weevil.—See under "Stored Cereals and Beans" (p. 114).

Wireworms.—See page 149.

Corn Earworm or Tomato Fruitworm, *Heliothis armigera* (Hbn.).—The larvae are about 1½ inches long when full grown and vary in color from yellowish to brownish, with longitudinal stripes of various colors, and with eight small dark tubercles on each segment. They work chiefly on the corn in the ear (fig. 67), but may also attack the tassels and leaves. This is the most

destructive insect attacking the ears of sweet corn. Early in the growing season, corn may not be seriously injured; but late in the season, after the population has built up, nearly 100 per cent of the ears may be infested. The most effective means of controlling the corn earworm is to inject (fig. 68) 0.85 to 1.00 cubic centimeter (about ¼ teaspoon) of a highly refined mineral oil directly into the "silk channel." For best results the oil should contain 0.2 per cent of pyrethrins and should have a viscosity of 100 to 200 and an unsulfonated residue of about 99 per cent. The oil interferes with fertilization and therefore should not be applied until fertilization is complete; it is best to wait until after the silk has begun to wilt and turn brown. When most of the ears in a field reach this stage at about the same time, it is only necessary to go through the field once. See also under "Tomato" (p. 125).

Fig. 68.—Injecting oil and pyrethrins into the ear of sweet corn for the control of the corn earworm. This shows the position at which the applicator should be held during operation. Avoid pushing the tip of the oiler more than ¼ or ½ inch into the silk channel of the ear.

COTTON[23]

Two-spotted Mite, *Tetranychus bimaculatus* Harvey.—Infestations on well-cared-for cotton are usually due to adjacent weed patches, alfalfa fields, and deciduous orchards. Cleaning up weeds in the winter is important to reduce infestations. See also under "Bean" (p. 23), and "Pacific Mite" under "Grape" (p. 73).

Bean Thrips, *Hercothrips fasciatus* (Perg.).—Bean thrips is described under "Bean" (p. 24). Sulfur dust does not appear to kill bean thrips but increases yields when applied to cotton, whether or not this insect is injuring the plants. Best control has been applications of dinitro-*o*-cyclohexylphenol dusts (p. 160).

Flower or Grass Thrips, *Frankliniella moultoni* Hood.—This species may injure cotton seedlings (fig. 69). See under "Peach and Nectarine" (p. 95).

Green Leafhoppers, *Empoasca abrupta* De Long, **and** *E. arida* De Long.—White stippling is followed by drying. Pyrethrum dusts have given good kills if the temperature is down to about 70° F or below and the air is quiet. Nicotine dusts are not effective.

Cotton or Melon Aphid, *Aphis gossypii* Glover.—This small, dark-green aphid (fig. 70) is often present in sufficient numbers to cause a sticky, sooty cotton fiber due to the quantities of honeydew which it produces. This condition of the cotton interferes with picking and ginning. Dust infested spots with 2 per cent nicotine dust. Destroying all infested plants in early summer may prevent serious infestations later. See under "Melon" (p. 84).

[23] For a more detailed discussion of cotton pests and their control see: Smith, Gordon L. California cotton insects. California Agr. Exp. Sta. Bul. 660:1–50. 1942.

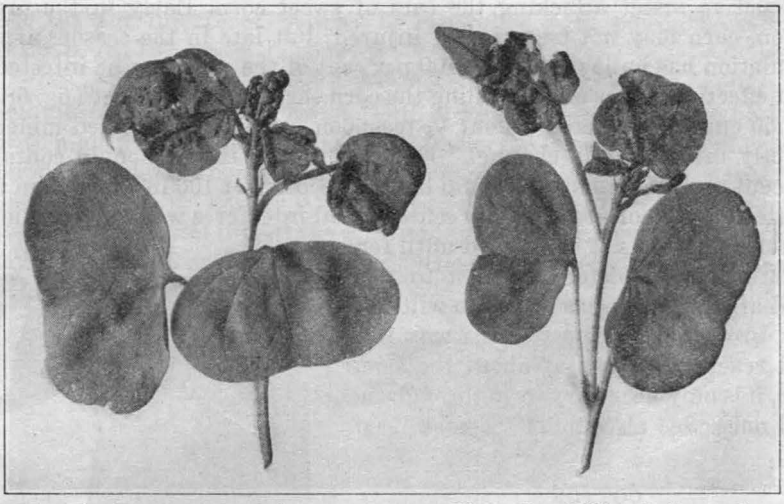


Fig. 69.—Flower-thrips injury to cotton seedlings. In addition to the curling of the leaves, the terminal bud is often destroyed, causing a stunting of the plant. (From Cir. 346.)

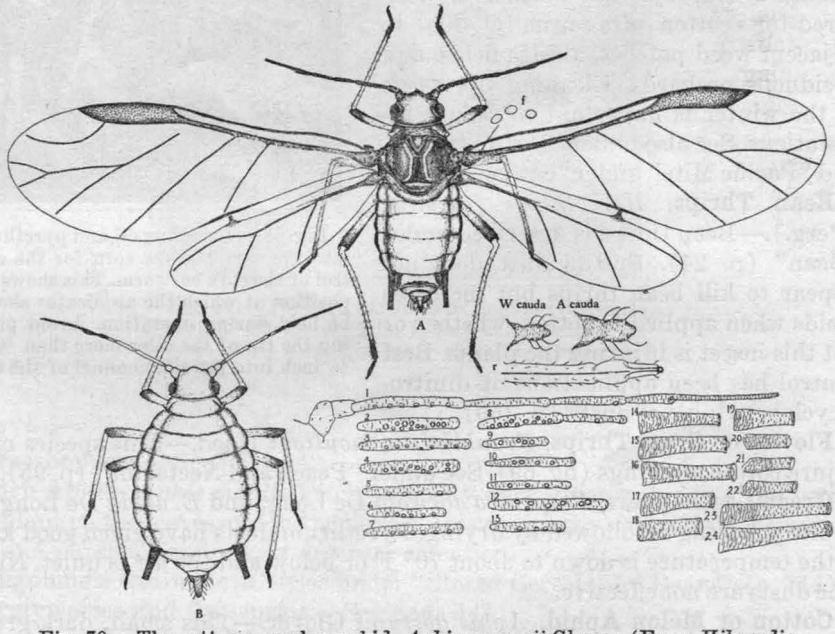


Fig. 70.—The cotton or melon aphid, *Aphis gossypii* Glover. (From *Hilgardia* Vol. 11, No. 9.)

Bur Clover or Cowpea Aphid, *Aphis medicaginis* Koch.—A shiny black aphid is sometimes a pest of cotton seedlings. Dust with 2 per cent nicotine dust.

Western Plant Bug or Cotton Dauber, *Lygus hesperus* Knight.—The adults (fig. 71, *A*) are very active, brownish-green plant bugs ¼ inch long and

one third as broad, with a yellow-green, heart-shaped mark between the bases of the wings (or near the middle of the back). The males are marked with dark and reddish spots on the body and wings. The back of the body beneath the wings is dark in both sexes. The nymphs are light green with red on the antennae; and the third, fourth, and fifth instars (fig. 71, *B, C, D*) have circular black spots on the back.

In June, when cotton is irrigated and succulent growth and fruiting buds (squares) start, adults are attracted from native and cultivated plants that are drying up, maturing, or being harvested. This insect sucks the sap from buds and small bolls, causes them to fall, and thereby stimulates leaf and stem growth. Fruiting is delayed and fiber from late bolls is injured by the weather.

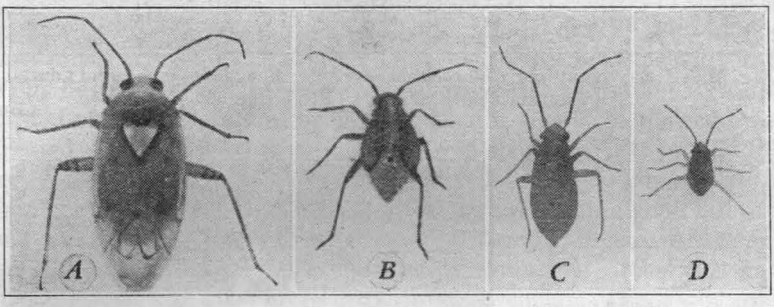


Fig. 71.—The western plant bug, or cotton dauber, *Lygus hesperus* Knight: *A*, adult; *B, C,* and *D,* fifth, fourth, and third stages, respectively, of the immature form. (Five times natural size.) (From Bul. 660.)

Some of the injured bolls remain on plants, but the gall tissue forming within the bolls increases with growth and develops into "knotty bolls" of reduced quantity and quality of fiber and seed.

Eggs are laid in succulent stems. Adults overwinter in alfalfa fields. Pasturing livestock on alfalfa and thorough cleanup of alfalfa fields one month before the first hay crop is cut will help to destroy the overwintering brood and the eggs they have deposited in alfalfa stems during warm days of late winter.

A mixture of 1 part of paris green and 12 parts of sulfur, dusted on cotton plants at 10- to 15-day intervals from the time adults may be collected in numbers of 25 or more per 100 plants until about August 1, has given the most practical control. This dust acts slowly and no effect on the bugs can be found during the first 3 days. A mixture of 1 part of calcium arsenate and 2 parts of sulfur may be substituted with slightly less control.

Straight oils containing pyrethrum (formula 10, p. 165), applied at the rate of 3 gallons per acre, are satisfactory when the air is quiet, between sunset and midnight, and the temperature is not above 70° F.

A dust containing organic thiocyanate (Lethane at 3 per cent) plus 0.5 per cent rotenone from ground root, or 0.2 per cent from extract, and about 65 per cent or more of sulfur gives good control when it is well applied during a quiet evening and the temperature is not above 70° F.

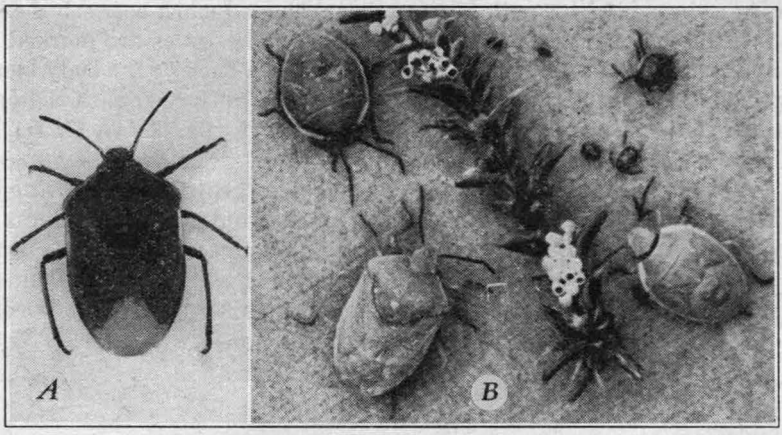


Fig. 72.—*A*, Say plant bug, *Chlorochroa sayi* Stål; *B*, eggs, nymphs, and adults. (Two times natural size.) (From Bul. 660.)

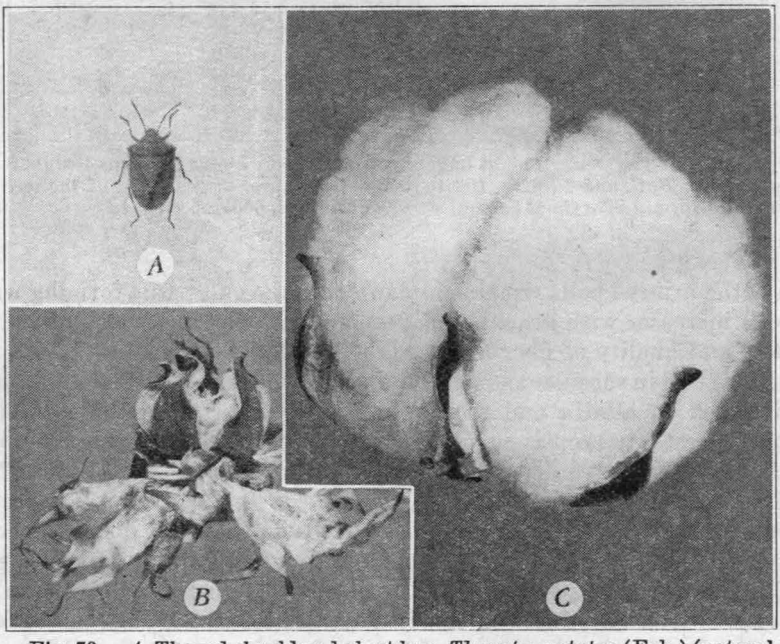


Fig. 73.—*A*, The red-shouldered plant bug, *Thyanta custator* (Fab.) (natural size); *B*, small cotton boll injured by the red-shouldered plant bug; *C*, a normal boll. (From Bul. 660.)

Say Plant Bug, *Chlorochroa sayi* Stål.—The adult is a shield-shaped bug (fig. 72) about ½ inch long and half as broad, green in summer, brown in winter, with three light spots between the bases of the wings (or across the back). The eggs, laid on the surfaces of plants, are light gray with darker gray bands and occur in masses of 28 and other multiples of 7. The nymphs

are at first black and with successive molts become green with some black and light bands and spots. For control see "Red-shouldered Plant Bug."

Red-shouldered Plant Bug, *Thyanta custator* (Fab.).—The adults (fig. 73, *A*) are about ⅜ inch long and half as broad, usually bright green in summer, but light-brown ones are found both winter and summer. The nymphs are checkered brown and white, with a small amount of black. Plant bugs, or stinkbugs, are found injuring the cotton bolls after the first crop is well formed. They produce knotty bolls (fig. 73, *B*) of stained fiber and destroy seeds. The first nymphs found on cotton in the San Joaquin Valley appear about August 1 and suck sap from succulent tissues and increase shedding of buds and bolls. Bug injury is usually localized but occasionally is of widespread importance. These bugs are more important pests of flax and alfalfa seed crops, and should be referred to under the latter. Control of these bugs is best obtained by destroying the overwintering adults during the winter when they are hibernating on the ground underneath weeds (especially tumbleweeds) by burning off the infested areas whenever it can be done. If stubble is not burned off immediately after harvest, then it should be plowed or otherwise treated so as to destroy these insects. From about April 15 to May 15 most of these bugs are young and wingless and many can be killed by cultivating or burning weedy areas. The DN dusts (p. 160) have given a good kill of these bugs without serious injury to cotton when light applications are used, but it is difficult to get dust onto the bugs. The dicyclohexylamine salts of this material do not give a good kill. Most crops are injured by chemicals that will kill these bugs.

False Chinch Bug, *Nysius minutus* Uhler.—This small brownish bug is a pest of potatoes, flax, and cotton in the southern San Joaquin Valley. Nicotine and soap spray (formula 16, p. 171) has been as effective as any insecticide tried, but none has given good control.

Beet Armyworm, *Laphygma exigua* (Hbn.).—Injury to cotton seedlings by the beet armyworm may be very important. See under "Beet" (p. 29).

Corn Earworm, Tomato Fruitworm, or Cotton Bollworm, *Heliothis armigera* (Hbn.).—This is rarely an important pest of cotton in California. There is, however, always some injury, and control may be warranted in certain cases. Dust with calcium arsenate at the rate of 4 to 6 pounds per acre when the air is calm and when the bolls are forming. Repeat if necessary at 15-day intervals. See under "Corn" (p. 56), and "Tomato" (p. 125).

Cotton Leaf Perforator, *Bucculatrix thurberiella* Busck.—Larvae are at first leaf miners; later stages eat holes through the leaf. It is not found in the San Joaquin Valley. Volunteer "stub" cotton should be avoided where this is a serious pest.

Darkling Ground Beetle, *Blapstinus rufipes* Casey, **and other Species.**—The larvae resemble very small wireworms and are called "false wireworms." The adults are small blackish beetles ⅛ to ¼ inch long, found on the ground under clods. The larvae may be destructive to cotton seedlings.

Adults of other, larger darkling ground beetles, including *Eleodes femorata* Lec. (fig. 74) and *E. omissa* Lec., may injure larger plants. For these poison baits (formula 28, p. 179, or 32, p. 181) and paper barriers are employed. These barriers consist of strips of wrapping paper 8 inches wide laid along and

extending about 3 inches over the vertical landside of a furrow. The paper is weighted down with soil to prevent the wind from carrying it away. The beetles are unable to crawl over the portion protruding over the furrow and are trapped in the furrows. Plowing of waste lands will reduce migrations of these large black beetles.

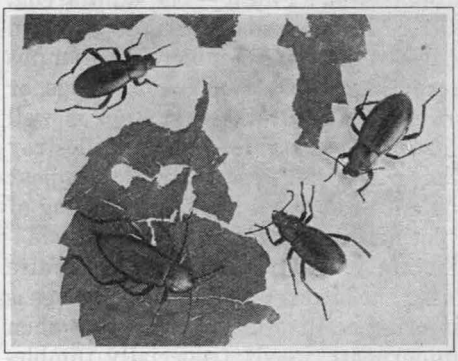


Fig. 74.—The darkling ground beetle, *Eleodes femorata* Lec., that often appears in great numbers in the upper San Joaquin Valley and sporadically devastates many kinds of crops.

COWPEA

Bean or Dock Aphid.—See under "Bean" (p. 25).

Bur Clover or Cowpea Aphid, *Aphis medicaginis* Koch. — This shiny black aphid occurs on a wide variety of plants. Dust with a 4 per cent nicotine dust.

Flea Beetles.—See under "Cucumber" below.

Bean Weevil.—See under "Stored Cereals and Beans" (p. 116).

Serpentine Leaf Miner.—See under "Pea" (p. 95).

CUCUMBER

Root-Knot Nematode.—See "Nematodes, Eelworms" (p. 136).

Two-spotted Mite.—See under "Bean" (p. 23).

Cotton or Melon Aphid.—See under "Melons" (p. 84).

Flea Beetles (various species).—These are small flealike beetles (fig. 75) which jump quickly and eat small holes in the leaves. Bordeaux mixture (formula 4, p. 158) as a repellent is a good control measure. Also dust with 4 per cent nicotine dust or a pyrethrum-thiocyanate dust containing 0.1 per cent pyrethrins and 1.0 per cent Lethane.

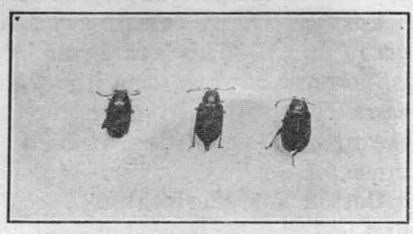


Fig. 75.—Adult flea beetles. These insects are very small. Their ability to jump is responsibile for the common name.

Western Spotted and Western Striped Cucumber Beetles, *Diabrotica 11-punctata* Mann. and *D. trivattata* (Mann.).—The former is a common small green beetle with twelve black spots on the back and is often mistaken for a ladybird; the latter is a brown beetle with three black lines on the dorsum. The adults may do considerable damage by eating tender leaves and blossoms. The white larvae feed upon the roots and may be controlled by pouring on the roots of each hill a cup of 40 per cent nicotine sulfate diluted 1 to 1,000 parts of water. Bordeaux mixture (formula 4, p. 158) is of considerable value as a repellent. Dusting with 33 or 40 per cent cryolite offers a good control; or dust with a pyrethrum-thiocyanate combination containing 0.1 per cent pyrethrins and 1.0 per cent Lethane. See also under "Melon" (p. 84).

CURRANT AND GOOSEBERRY

Two-spotted Mite.—See under "Bean" (p. 23). Dust with sulfur or spray with oil or commercial or homemade wettable sulfur (formula 19, p. 174).

San Jose Scale.—See under "Apple and Quince" (p. 11).

Imported Currant Borer, *Aegeria tipuliformis* (Linn.).—White caterpillars nearly 1 inch long work down the middle of the stalks and into the roots of the plants. Cut out and burn all dead and infested canes during winter and remove the borers in those left.

Western Flat-headed Borer.—See under "Apple and Quince" (p. 15).

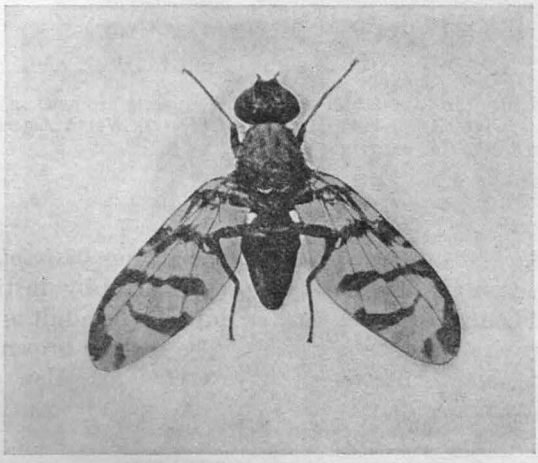


Fig. 76.—The currant or gooseberry fruit fly, *Epochra canadensis* (Loew). (After Whitney.)

Currant or Gooseberry Fruitfly, *Epochra canadensis* (Loew).—Small white maggots occur in the fruit at picking time. The adults are shown in figure 76. Cultivate thoroughly during the fall, winter, and spring months to expose and destroy the hibernating pupae.

DAHLIA

Leaf and Bud Nematode.—See "Nematodes, Eelworms" (p. 136).

Thrips.—Various species of flower thrips attack the opening buds and cause a deforming and browning of the petals. Fairly good control can be obtained by spraying frequently with nicotine sulfate, rotenone, or pyrethrum.

Bean Aphid.—See under "Bean" (p. 25).

Western Spotted Cucumber Beetle, *Diabrotica 11-punctata* Mann.—This green beetle is often a serious pest to the flowers. See under "Melons" (p. 84) and "Apricot" (p. 16). Barium fluosilicate or cryolite dusts give some control, but no satisfactory method has been devised for adequately protecting choice individual flowers except screening with cloth.

Wireworms.—See page 149. The effects on a dahlia tuber are shown in figure 77.

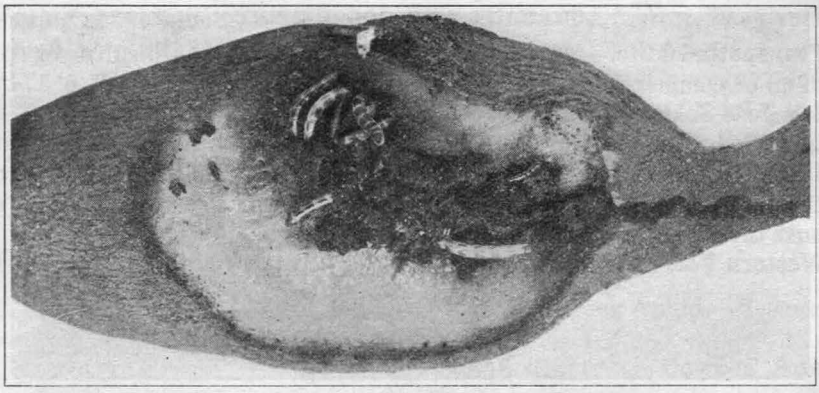


Fig. 77.—Wireworms in a dahlia tuber. These insects are most injurious in light sandy or humus soils. (After Essig, *Insects of Western North America*, by permission of the Macmillan Co., copyright owners.)

DATE

Date Mite, *Paratetranychus heteronychus* Ewing [=*simplex* (Banks)].—This pale-colored mite is an important pest. Control by dusting with sulfur.

Date Fulgorid, *Asarcopus palmarum* Horv.—The adult is dark brown, 1/6 to 1/4 inch long, with rudimentary wings. The reddish-brown nymph attacks the crown leaves and fruit stems, and excretes honeydew over the fruits. Control is usually unnecessary.

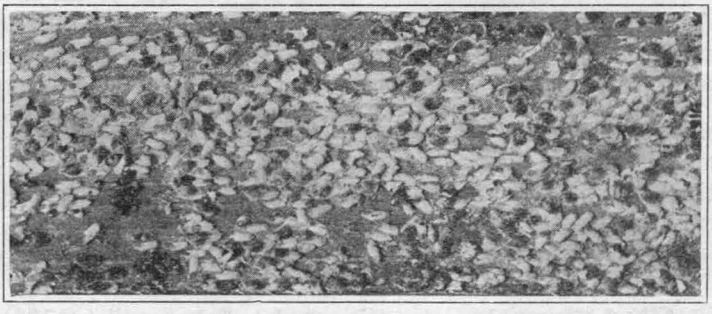


Fig. 78.—The date palm scale, *Parlatoria blanchardii* (Targ.), a typical heavy infestation on leaf of date palm. An eradication campaign has now eliminated this scale from date orchards.

Red Date Scale, *Phoenicococcus marlatti* Ckll.—This is the commonest scale insect on date palms in the Coachella Valley. It occurs mostly below the fiber on the white tissue, sometimes on the roots. While it may occur in large numbers, it does not appear to be injurious to the palm.

Date Palm Scale, *Parlatoria blanchardii* (Targ.).—A small gray and white scale, less than 1/16 inch long, often occurs in great numbers on the leaves (fig. 78). It is believed to have been eradicated in California in 1934. Any reappearance of the insect pest should be reported to the local horticultural officials.

DRIED FRUITS

(See also "Stored Cereals and Beans," p. 114, and "Nuts in Storage," p. 87)

Dried-Fruit Mite, *Carpoglyphus passularum* Hering.—This light-colored, almost microscopic mite sometimes seriously infests dried fruits. When present in large numbers, the mites impart a somewhat disagreeable odor to the fruit.

Fig Moth, *Ephestia cautella* Walk.—The adults are about ½ inch long. The color of the forewings varies, most individuals being mottled gray, while

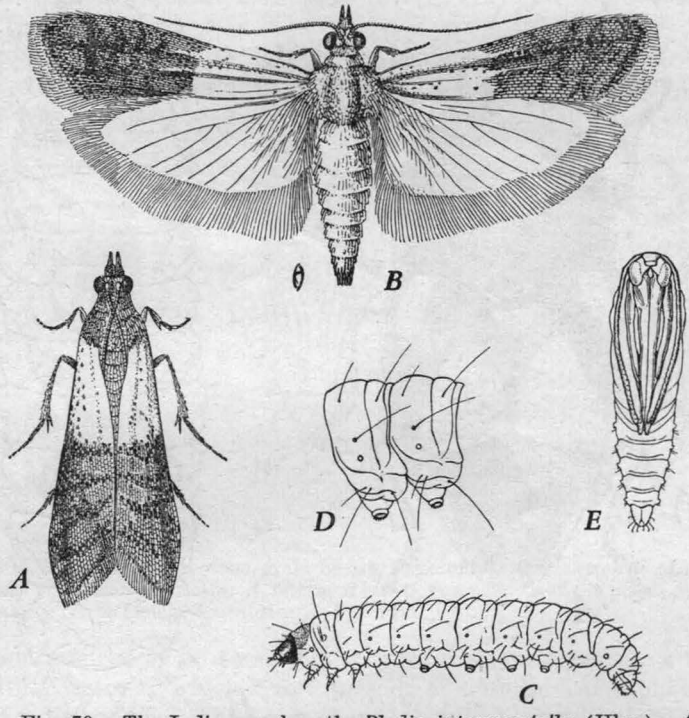


Fig. 79.—The Indian-meal moth, *Plodia interpunctella* (Hbn.): *A*, adult in normal resting position; *B*, adult with wings spread; *C*, larva or caterpillar; *D*, enlarged drawing of two body segments in the region of the prolegs; *E*, pupa or chrysalis. (*A*, *B*, *C*, and *E*, six times, and *D*, eleven times, natural size.) (From Bul. 676.)

others are suffused with fawn-colored scales. The larvae feed on dried fruits, nuts, and cereal products. For control see end of this section.

Indian-Meal Moth, *Plodia interpunctella* (Hbn.).—The adults have a wing spread of about ⅝ inch. The basal portion of the forewings is pale and the outer portion is dark in color. Damage is done by the larvae, which are pale in color and when full-grown are about ½ inch in length. The larvae spin considerable webbing over infested foods, which include dried fruits, nuts, and cereal products. Several stages of this insect are shown in figure 79. For control see end of this section.

Mediterranean Flour Moth, *Ephestia kühniella* Zell.—This moth is very similar in habits to the Indian-meal moth and slightly larger. The adults are

grayish with a mottling of small black dots and streaks on the forewings. They have a wing expanse of about ¾ inch. For control see end of this section.

Raisin Moth, *Ephestia figulilella* Greg.—The moth is similar to the Mediterranean flour moth but is somewhat different in habits. It infests fruits during drying and storage on ranches. Control involves the reducing of its numbers in the field and preventing its access to or survival in the drying crop. Reinfestation is slight or absent in thoroughly dried fruit. The abundance of the

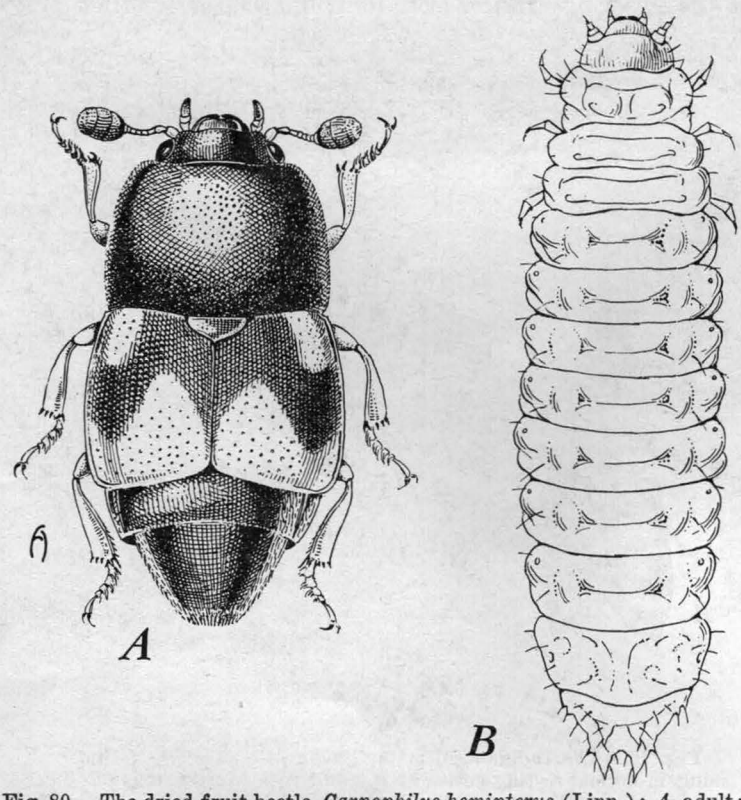


Fig. 80.—The dried-fruit beetle, *Carpophilus hemipterus* (Linn.): *A*, adult; *B*, larva. (Twenty times natural size.) (From Bul. 676.)

raisin moth in the field is reduced by elimination of all waste fruits and fruit pits. Fruits which dry in the shade under trees, and grapes under vines are suitable for breeding, while fruits exposed to the sun breed few moths. The fruits of mulberries favor infestations; so either the removal of fruiting trees or the destruction of the dropped fruits at 10-day intervals will reduce the infestation from this source. Infestation of fruit occurs largely in stacked trays and after boxing, and this infestation can be greatly reduced by covering tray stacks and boxes with tobacco shade-cloth. For further control see end of this section.

Dried-Fruit Beetle, *Carpophilus hemipterus* (Linn.).—The adults (fig. 80) are small, broad, flat beetles about ⅛ inch long with short wing covers and knobbed antennae. They are brown in color with pale spots. Both the adults

and larvae attack dried fruits. No webbing is to be found associated with these beetles. For control see end of this section.

Saw-toothed Grain Beetle, *Oryzaephilus surinamensis* (Linn.).—This small, dark brown, slender, flat beetle, with a row of sawlike teeth along the sides of the pronotum (fig. 81), is a serious pest of dried fruit. Both the adult and the short-legged, pale-colored larvae attack dried fruits, nuts, cereals, and cereal products. For control see end of this section.

Confused Flour Beetle.—See figure 137 (p. 116) and "Stored Cereals and Beans" (p. 115).

Control.—Everything possible should be done to minimize infestations in orchard, while drying, and during storage. Orchard and drying-yard sanitation are very important. The dried fruit should be handled in clean boxes.

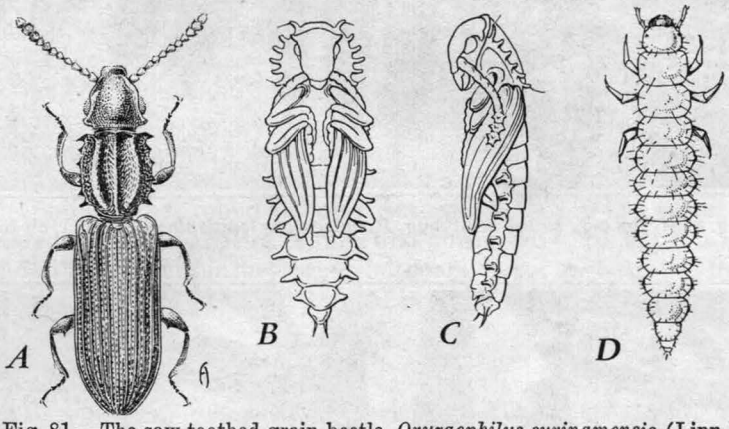


Fig. 81.—The saw-toothed grain beetle, *Oryzaephilus surinamensis* (Linn.), a very small slender beetle: *A*, adult; *B* and *C*, two aspects of the pupa; and *D*, larva. (Fifteen times natural size.) (From Bul. 676.)

This can be assured by immersing the boxes for a few seconds in a tank filled with boiling water to which 1 to 3 pounds of trisodium phosphate per 100 gallons has been added. The boxes should then be rinsed in clean water. All dried fruit should be fumigated when removed from the drying yard, and should be held in structures provided with fumigable storage so that it can be refumigated when necessary.

Structures used for fumigation chambers must be gastight. Unless they are, poor control will be obtained. All fumigants are hazardous and should be used with the greatest of caution. An inexperienced person should never attempt to use any fumigant unless he has been taught how to use it by some competent operator. Chloropicrin, ethylene oxide, and methyl bromide are recommended for the fumigation of dried fruits.[24] It is not advisable to use HCN gas for fumigating dried fruits because of the possibility of toxic residues, which may cause subsequent seizure by the Federal Food and Drug Administration.

Clean fruit stored at 40° to 45° F will remain free of dried-fruit insects, and if fruit is infested these temperatures will prevent growth and reproduction of the pests.

[24] Mrak, E. M., and J. D. Long. Methods and equipment for the sun-drying of fruits. California Agr. Exp. Cir. 350:1–69. 1941.

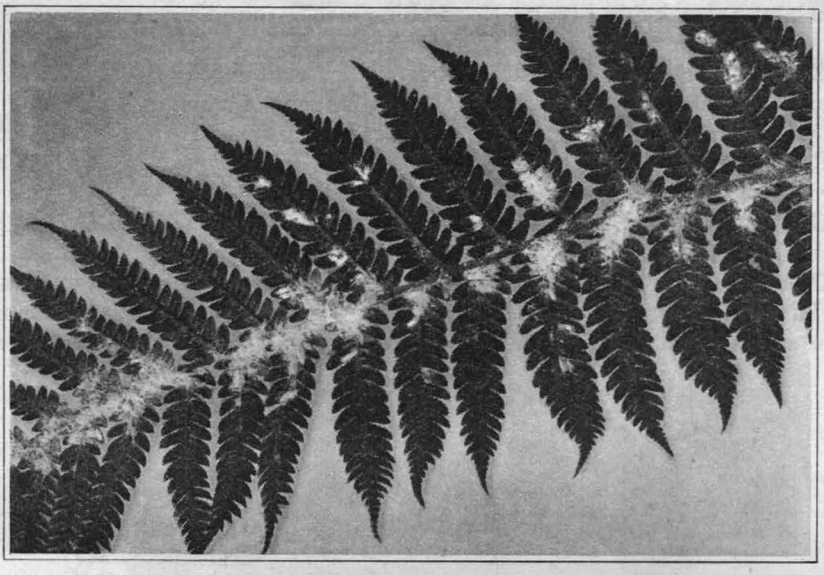


Fig. 82.—The long-tailed mealybug, *Pseudococcus longispinus* (Targ.), on fern.

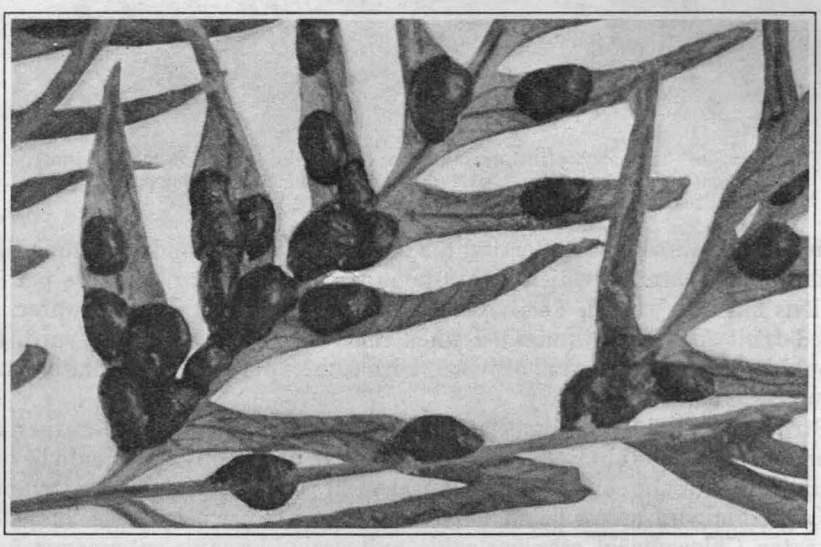


Fig. 83.—The mature forms of the hemispherical scale, *Saissetia hemisphaerica* (Targ.), on fern.

EGGPLANT

Western Spotted Cucumber Beetle.—See under "Cucumber," p. 62.

False Plume Moth, *Lineodes integra* Zell.—The small "sticky" green caterpillars feed on the terminal leaves and injure the heads. They also occur on tomato and related plants. At first glance the small adults resemble plume

moths, but they have the wings entire and not divided into plumes. Spray with pyrethrum and oil (formula 18, p. 172) or dust with rotenone (0.5 or 1.0 per cent rotenone mixed with talc) or cryolite when the larvae first appear.

FERNS

Two-spotted Mite.—See under "Beans" (p. 23).

Fern Aphid, *Idiopterus nephrelepidis* Davis.—A minute black species of aphid infests the tender tips of the fronds and causes curling. Dip in or spray with formula 16 (p. 171) or with 1 pound of powdered soap to 5 gallons of water.

Mealybugs.—See page 142. Figure 82 shows a fern leaf infested with mealybugs.

Hemispherical Scale, *Saissetia hemisphaerica* (Targ.).—A brown, nearly hemispherical scale (fig. 83) often appears in great numbers on the undersides of the fronds and on the stems. Spray or dip, using a solution of oil emulsion and nicotine (formula 13, p. 168, with summer oil).

Fern Moth, *Euplexia benesimilis* McD.—The adult is a rich velvety maroon moth. The caterpillars may be either green or brownish red, and commonly feed upon ferns indoors and out. Two broods a year are found, the fall-brood larvae dropping to the ground and overwintering in the soil in a silken cocoon impregnated with soil particles. Adults first appear in April, but it is usually not until fall that serious injury occurs outdoors. It can be controlled by using lead arsenate (formula 1) (dyed green if preferred).

FIG

Root-Knot Nematode, *Heterodera marioni* Cornu.—These microscopic nematodes are becoming increasingly serious, causing small nodules or large swellings on the roots. No remedy is known. See page 136.

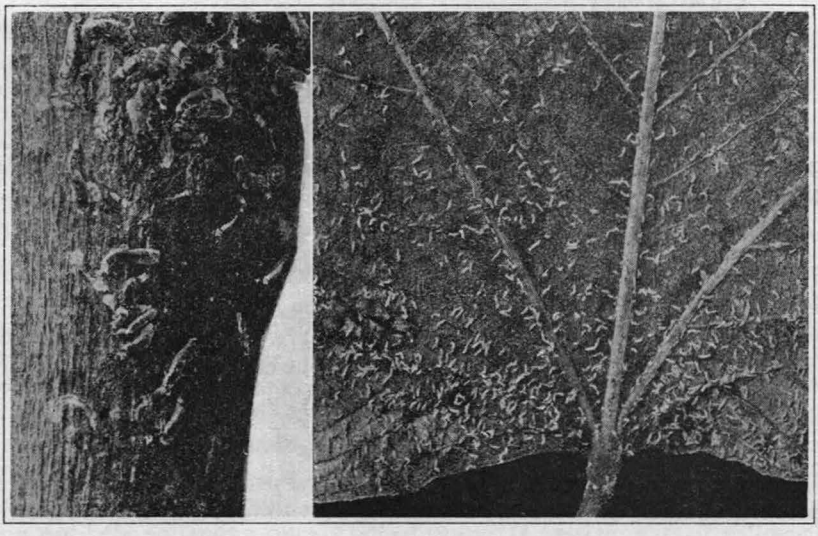


Fig. 84.—The Mediterranean fig scale, *Lepidosaphes ficifoliae* (Berlese), on twig and leaf.

Mites, or Red Spiders.—See "Pacific Mite" under "Grape" (p. 73), and "Two-spotted Mite and Pacific Mite" under "Plum and Prune" (p. 102).

Mediterranean Fig Scale, *Lepidosaphes ficifoliae* (Berlese).—Scales resembling small oysters (fig. 84) infest the limbs, twigs, leaves, and fruit. Spray with 4 per cent tank-mix oil (p. 167) or emulsive oil, or 6 per cent commercial oil emulsion, during the winter when the trees are dormant.

Branch and Twig Borer.—See under "Apricot" (p. 16).

Dried-Fruit Insects.—See under "Dried Fruits" (p. 65).

Pomace or Vinegar Fly, *Drosophila ampelophila* Loew.—Small, slender, whitish maggots and brown or orange-colored flies $\frac{1}{10}$ inch long often occur

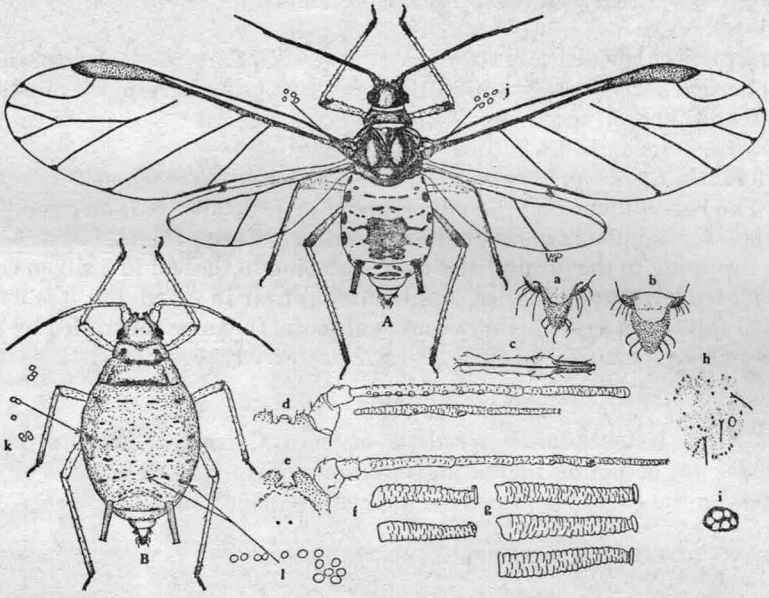


Fig. 85.—The ornate aphid, *Myzus ornatus* Laing, a very small green species commonly infesting the terminal growth of fuchsias in the San Francisco Bay region.

in great numbers in figs on the trees and on the drying trays. No practical method of control has yet been devised.

FLAX

Grasshoppers.—See page 142.

Say Plant Bug, *Chlorochroa sayi* Stål, **and the Red-shouldered Plant Bug,** *Thyanta custator* (Fab.).—These two plant bugs are likely to become pests of the seed crop if flax is planted close to barley. The cutting of the barley forces the bugs to feed upon the flax. See under "Cotton" (p. 60–61).

FUCHSIA

Cyclamen or Strawberry Mite, *Tarsonemus pallidus* Banks.—A microscopic, transparent mite infests the tender growth and may cause russeting. The control is rather difficult and would be similar to that advised for this mite under "Strawberry" (p. 118).

Privet Mite, *Tenuipalpus bioculatus* McG.—This minute crimson mite has two well-defined eyespots. It commonly infests privet, but also occurs at times on the fuchsia. For control see "Two-spotted Mite and Pacific Mite," under "Bean" (p. 23), and "Plum and Prune" (p. 102).

Two-spotted Mite.—See under "Plum and Prune" (p. 102).

Greenhouse Thrips.—See under "Avocado" (p. 21) and see "Bean Thrips" under "Bean" (p. 24).

Ornate Aphid, *Myzus ornatus* Laing.—A very small, green aphid (fig. 85) often occurs in considerable numbers in the spring and causes the leaves to curl. Dust with a 1 to 2 per cent nicotine dust or spray with commercial oil and nicotine (formula 13, p. 168) or with pyrethrum and oil sprays (formula 18, p. 172) or with a solution of 1 pound of powdered soap to 5 gallons of water.

GARLIC

(See "Onion, Garlic, Leek, Shallot," p. 92)

GERANIUM

Geranium Aphid, *Macrosiphum pelargonii* (Kalt.).—A green aphid is often very abundant on the growing tips of geraniums. It also commonly infests the various types of filaree, *Erodium* spp. For control see "Ornate Aphid" under "Fuchsia" (p. 70).

Tobacco Budworm, *Heliothis virescens* (Fab.).—A light-green or pinkish caterpillar, about 1½ inches long when full grown, eats holes in the leaves and flowers of geraniums. It may be controlled by spraying or dusting the plants with cryolite (formula 5 or 6) at regular intervals.

GLADIOLUS

(See "Bulb," p. 32)

GOOSEBERRY

(See "Currant and Gooseberry," p. 63)

GOURDS

(See "Melons," p. 83)

GRAIN (BARLEY, GRAIN SORGHUMS, MILLET, OATS, RICE, WHEAT)

(See "Corn," p. 56, and "Stored Cereals and Beans," p. 114)

Grain Mites.—See under "Stored Cereals and Beans" (p. 114).

Corn Aphid, *Aphis maidis* Fitch.—This species (fig. 86) is often a very serious pest of barley, wheat, and oats, especially in the southern part of the state. Control measures are usually of little avail, but crop rotations and time of planting may be helpful. Premature cutting may also save part of the crop. See under "Corn" (p. 56).

Black Grass Bug, *Irbisia solani* (Heid.), **California Plant Bug,** *Irbisia californica* V. D., **and Other Species.**—These bugs breed on native grasses throughout the West, passing through the nymphal stages during February and attacking a wide variety of field and garden crops during March, April, and May. Oviposition is completed by early summer, and the bugs are not seen again until the following year. Typical injury to oats consists of yellow spotting and drying up of leaves. The greatest injury occurs when native grasses

dry up, which forces the bugs to migrate to field and garden crops and to developing fruit in orchards. Twenty-five per cent calcium cyanide dust has given most satisfactory control.

Angoumois Grain Moth, *Sitotroga cerealella* (Oliv.).—In some parts of the country, this insect (fig. 87) attacks the maturing grain in the field and continues to breed in storage after harvest. In California infestations appear to occur mostly in storage. See under "Stored Cereals and Beans" (p. 114).

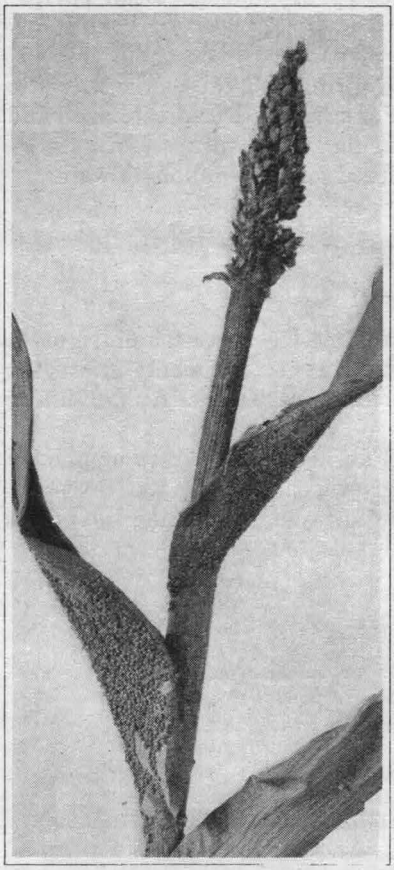


Fig. 86.—The corn aphid, *Aphis maidis* Fitch, on milo. It is mostly killed by an internal parasite.

Straw Worms and Joint Worms, *Harmolita* spp.—These very small antlike insects deposit eggs in the heart of the young plants, and the minute, white, legless larvae live within the stems and cause malformations of the joints or of the leaf sheaths of wheat, rye, and wild grasses. Barley is not attacked and is a satisfactory rotation for any of the susceptible grains. Control is the same as for hessian fly.

Range Cranefly, *Tipula simplex* Doane.—This and other closely related species have wingless females and winged males. They look like oversized mosquitoes. The larvae are called "leatherjackets," from their brownish color and tough skins. They live in damp soil of grasslands and even grainfields in winter and early spring. They excavate cylindrical holes, from which they feed upon the surrounding grasses. They may be so numerous as to completely destroy the plants over considerable areas and to reduce pasturage and set back the grain. Control is readily obtained by broadcasting poison baits as recommended for grasshoppers (formula 27 or 28, p. 179).

Hessian Fly, *Phytophaga destructor* (Say).—A small gnatlike fly lays very minute spindle-shaped eggs on the leaves of the wheat in the fall and spring months. The small white maggots feed on the stems and often do considerable damage to wheat and to late-sown barley in some localities. Deep plowing-under of stubble immediately after harvest, summer fallow, or a rotation of crops will serve to keep the insect in check. This fly is more injurious in California than is generally known. It occurs in twenty-one counties and is most injurious in the eastern Sacramento Valley from Solano County into Tehama where from 80 to 90 per cent of the crop may be infested and as much as 4 per cent destroyed. Wheat varieties resistant to this pest are being bred.

GRAPE

(For raisins see "Dried Fruits," p. 65)

Grape Erinose Mite, *Eriophyes vitis* (Land.)—A microscopic mite hibernates in the buds and emerges in the spring. It feeds in the buds and on the undersides of the leaves (fig. 88) and causes a superfluous growth of leaf hairs; this growth produces an erineum (felty patches) which varies from yellow or

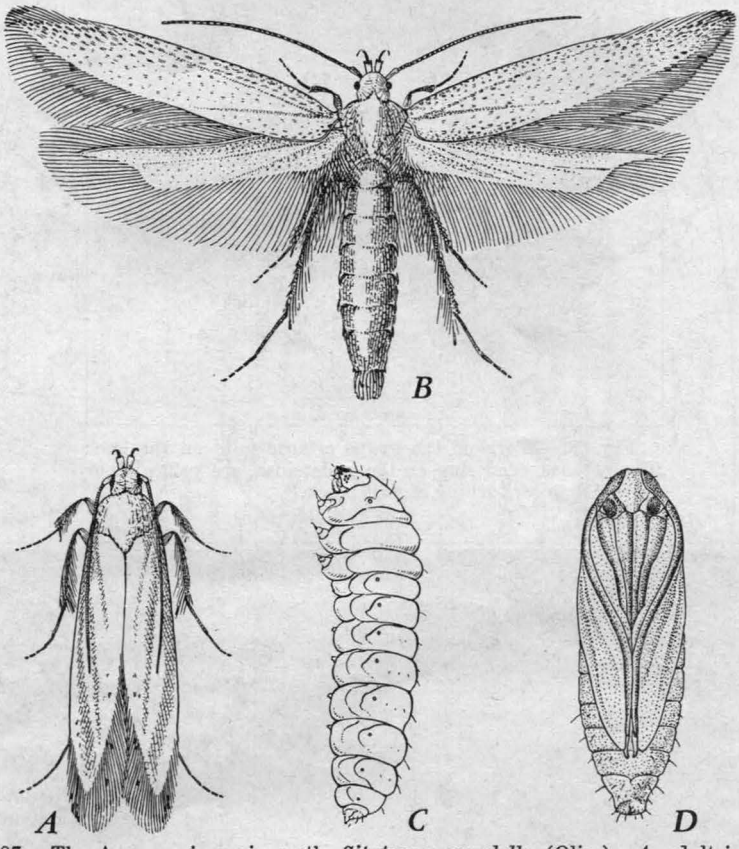


Fig. 87.—The Angoumois grain moth, *Sitotroga cerealella* (Oliv.): *A*, adult in normal resting position; *B*, adult with wings spread; *C*, larva; *D*, pupa. (All eight times natural size.) (From Bul. 676.)

brown to almost black in color. Applications of dusting sulfur ordinarily hold this mite in complete control.

Pacific Mite, *Tetranychus pacificus* McG.—This mite turns the leaves red or brown and defoliates the vine. The tiny, amber-colored, black-spotted mites feed on the undersides of the leaves. Winter is passed under the bark of the vines (fig. 89). Spray with oil twice in the spring using an oil of viscosity 65 to 75 seconds Saybolt and U.R. 90 at 1½ gallons per 100 gallons of water plus a good spreader; first application should be made when shoots have about six leaves, the second application 10 days later. Or band the base of each spur

with sticky material; then when the mites emerge from hibernation and congregate on suckers below the bands, carefully pick off and destroy the suckers and the mites with them. See discussion under "Selenium" (p. 173).

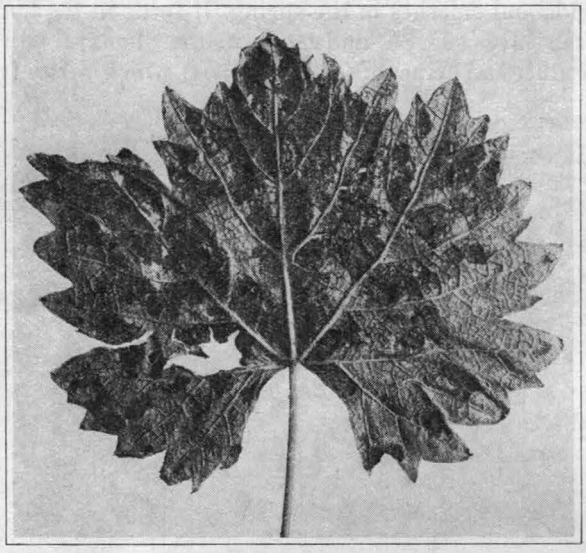


Fig. 88.—Work of the grape erinose mite on the leaf. The patches, occurring on the undersides, are yellowish or brownish, later turning almost black.

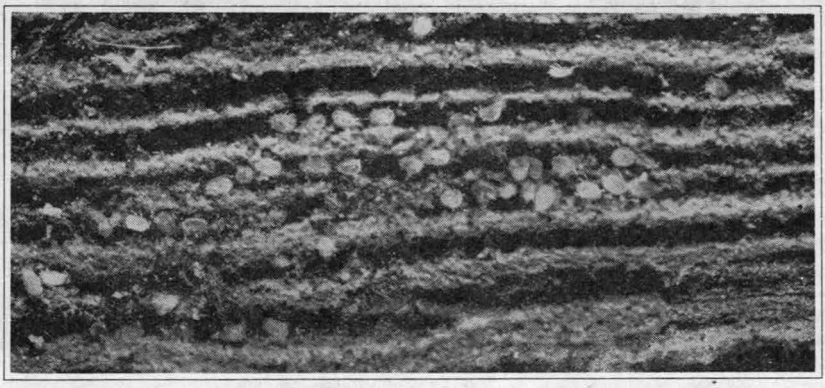


Fig. 89.—Immature forms of the Pacific mite, *Tetranychus pacificus* McG., hibernating under the bark of a grapevine. The bark has been removed to show the inner side.

Grasshoppers.—See page 142.

Grape Thrips, *Drepanothrips reuteri* Uzel.—This minute, orange-yellow insect scars the berries when less than one-third grown and causes browning of the small leaves and canes in midsummer. Table grapes, especially white varieties, are more commonly damaged. Spraying or dusting with pyrethrum or rotenone, or spraying with tartar emetic and sugar (formula 21, p. 176)

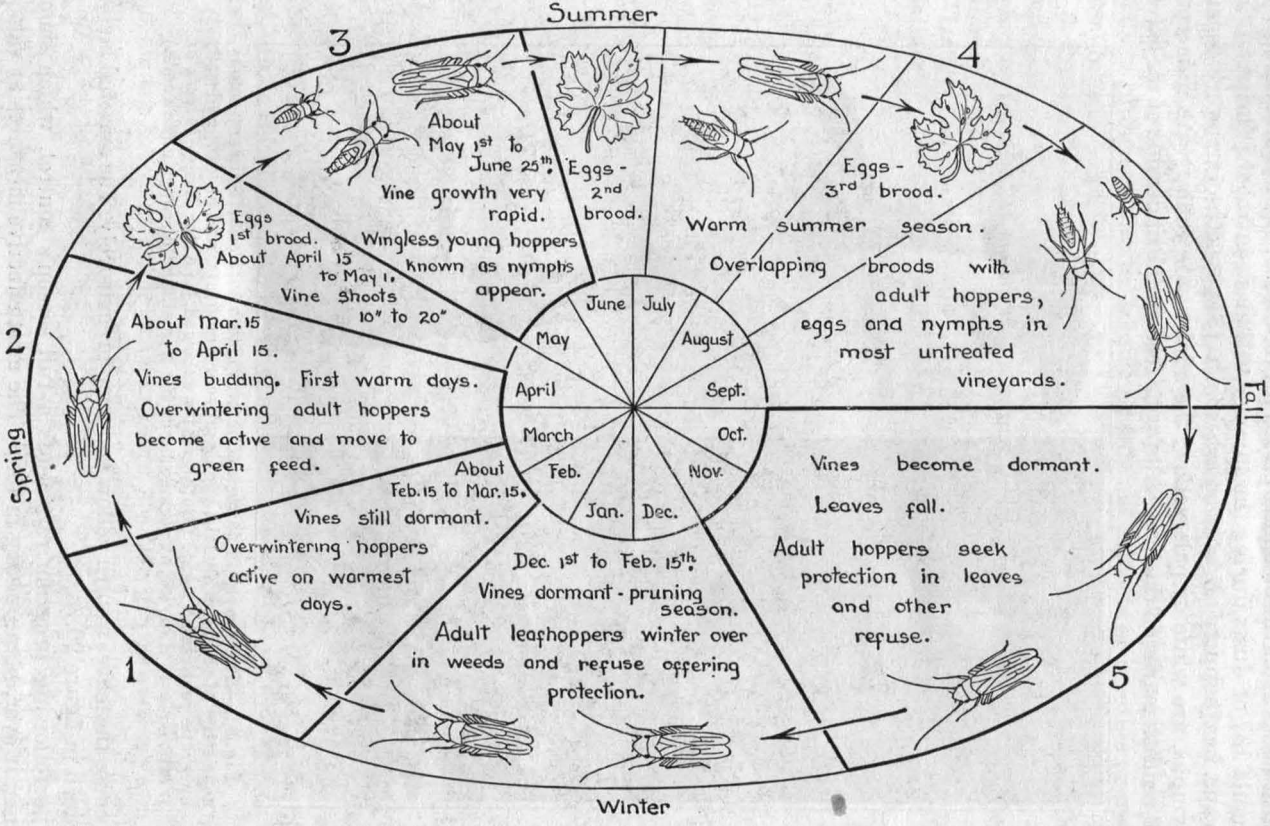


Fig. 90.—Chart showing the life history of the grape leafhopper, *Erythroneura comes* (Say). (From Ext. Cir. 72.)

within 2 weeks after the blooming period prevents scarring. Pyrethrum sprays (formula 18) or dusts during the summer will also control the thrips.

Grape Leafhopper,[25] *Erythroneura comes* (Say).—The immature forms, or nymphs, are white or pale yellow, the adults pale yellow with numerous small reddish marks on the back. All forms feed on the underside of the leaves

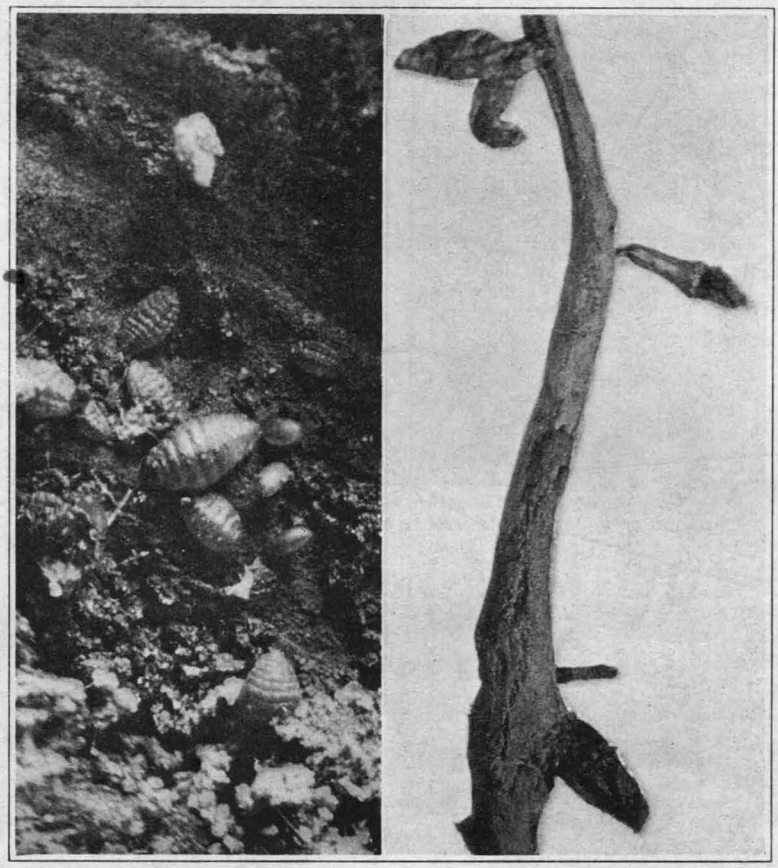


Fig. 91.—The grape phylloxera, *Dactylosphaera vitifoliae* Shimer; colony, consisting of the adult female, eggs, and young on grape root at left; and galls on grape rootlets at right. (Both greatly enlarged.) (After Essig, *Insects of Western North America*, by permission of the Macmillan Co., copyright owners.)

and cause the leaves to turn yellow and drop prematurely. The seasonal history is shown in figure 90.

The following program represents a full season's control, which should seldom, if ever, be necessary in total. The most effective measures at various seasons of the year are indicated.

1. Clean cultivation followed by covercrops in the fall.
2. Planting a trap crop and treating it with calcium cyanide granules or

[25] See also: Lamiman, J. F. Control of the grape leafhopper in California. California Agr. Ext. Cir. 72:1–20. 1933.

with pyrethrum and oil spray (formula 18) to destroy the overwintering adults before vine growth starts.

3. Early spring treatment of adults with pyrethrum and oil spray (formula 18, p. 172) after movement to vines.

4. Two nymphal treatments with nicotine and casein spray (formula 17, p. 171) or proprietary water-soluble pyrethrum extracts or nicotine or pyrethrum dusts.

5. Treatment of first-brood adults with calcium cyanide dust or pyrethrum and oil vapor spray (formula 10, p. 165) if weather conditions permit.

6. Treatment of second-brood nymphs with nicotine or pyrethrum dust, or oil and pyrethrum vapor spray.

7. Calcium cyanide treatment of adults at rate of 20 pounds granular material per acre before harvesting crop.

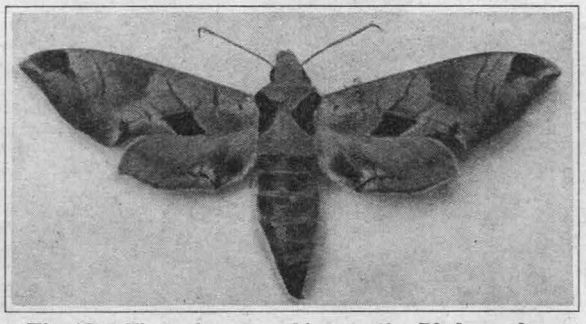


Fig. 92.—The achemon sphinx moth, *Pholus achemon* (Drury), a beautiful brown species with pink hindwings. (From Bul. 192.)

Treatments 3 and 4 are exceedingly effective, and one or both of them are usually sufficient, if thoroughly applied, for practical control.

Grape Phylloxera, *Dactylosphaera vitifoliae* Shimer (*Phylloxera vitifoliae* [Fitch]).—The presence of the phylloxera (fig. 91) is indicated by weak and dying vines. It usually occurs in small areas. The insect is a minute, yellow louse which feeds on the roots. To disinfect cuttings or rootings before planting, dip in hot water, 122° F, for 5 minutes. For permanently resistant vines, graft European varieties on certain American resistant roots.

Grape Mealybug, *Pseudococcus bakeri* Essig.—This insect is small, oval, flat, and covered with white, cottonlike wax threads. Cottony egg masses are laid among the bunches of grapes. There are two generations a year. The winter is spent under rough bark. Spray before the buds open with 5 gallons of winter-type oil emulsion per 100 gallons of water with or without 3 gallons of lime-sulfur solution per 100 gallons of water. Control ants, which protect the mealybugs from their natural enemies. (See "Ants," p. 151, and "Mealybugs," p. 142.)

Achemon Sphinx Moth, *Pholus achemon* (Drury).—The large caterpillars are green or pinkish with oblique whitish bars on the sides. They are often abundant and do great damage by defoliating the vines. The adult moths (fig. 92) are dull gray with brown marks and pink hindwings. Spray vines with 4

pounds of standard lead arsenate per 100 gallons of water, or dust with powdered lead arsenate, 1 part to 4 parts of hydrated lime, or with dusting sulfur.

Armyworms and Cutworms.—See page 144.

Grape Leaf Folder, *Desmia funeralis* (Hbn.).—This pale-green worm, about 1 inch long, folds over the edges of the grape leaves to form a roll about the size of a lead pencil (fig. 93). There are two generations each year, but the first brood of worms is not common enough to do much damage. Spray before the fruit reaches the buckshot stage with 3 pounds of standard lead arsenate per 100 gallons of water, plus a good spreader, or add 1½ pounds of standard lead arsenate or cryolite to each gallon of oil-pyrethrum vapor spray (formula 10) used for grape leafhopper adults of the overwintering brood,

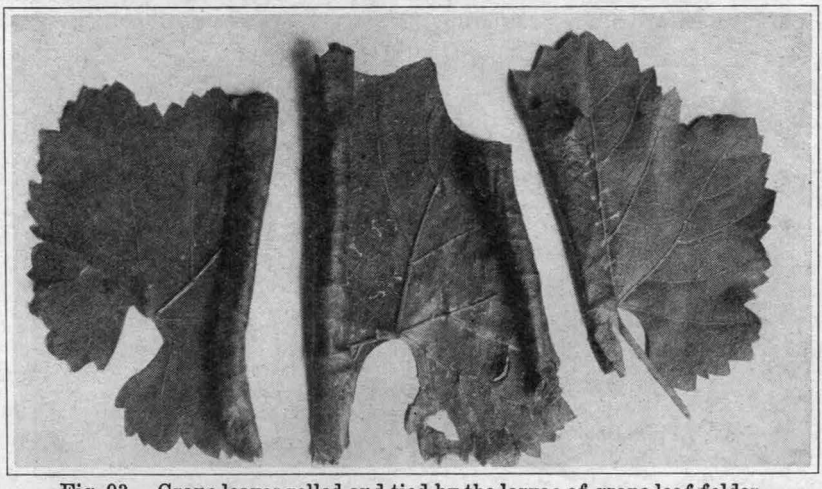


Fig. 93.—Grape leaves rolled and tied by the larvae of grape leaf folder, *Desmia funeralis* (Hbn.). (From Bul. 192.)

or dust with cryolite and sulfur dust (see discussion of formula 6) when the eggs are hatching; but avoid dusting so late as to leave a poisonous residue on the fruit at harvest.

Indian-Meal Moth.—See under "Dried Fruits" (p. 65).

Raisin Moth.—See under "Dried Fruits" (p. 65).

California Grape Rootworm, *Adoxus obscurus* (Linn.).—The adult beetles are black or brown and 3/16 inch long. They eat long narrow slits in the leaves (fig. 94). The small white grubs feed on the roots of the vines. As soon as the beetles appear in the spring, spray the foliage with 3 pounds of standard lead arsenate and ¼ pound of casein or commercial spreader per 100 gallons of water, or dust with 1 part of powdered lead arsenate to 4 parts of hydrated lime or sulfur, or apply a spray of 1½ pounds of derris powder (containing 4 per cent rotenone) and 50 gallons of water. **Caution:** Do not spray grapes with poisonous sprays after the fruit reaches the buckshot stage, because of residue.

Grape Bud Beetle,[26] *Glyptoscelis squamulata* Crotch.—The light-gray bee-

[26] See also: Ebeling, W. The grape bud beetle, *Glyptoscelis squamulata* Crotch. California State Dept. Agr. Bul. 28:459–65. 1939.

tles are ¼ inch long. The eggs are laid in the bark, and the larvae, upon hatching, drop to the ground and feed on the roots of the vine. The chief damage is done by the adult beetles, which feed on the opening buds in the early spring. Banding with proprietary sticky banding materials at the base of the spurs and freshening these bands when necessary will control this pest. A paper bag tied over each spur in the early spring and removed when the new growth reaches the end of the bag is effective in household plantings.

Fig. 94.—Linear holes in grape leaf cut by the adults of the California grape rootworm, *Adoxus obscurus* (Linn.). (From Bul. 195.)

GRAPEFRUIT

(See "Citrus Fruits," p. 50)

HOLLYHOCK

West Coast Lady, *Vanessa carye* (Hbn.).—The yellowish or black, spiny caterpillars, about 1 inch long, feed on the leaves, which they draw together with webs for protection. The adult is a common reddish-orange and gray butterfly. Control is best accomplished by using 40 per cent nicotine sulfate, 1 part to 600 parts of water, and spraying the plants thoroughly. Dusting with calcium arsenate or cryolite will also check the work of the caterpillars.

HOP

Two-spotted Mite.—See under "Bean" (p. 23).

Hop Aphid, *Phorodon humuli* (Schr.).—This pale-green aphid (fig. 95) attacks the young shoots and leaves. Dust thoroughly and as often as necessary with 2 per cent nicotine dust (see p. 171); or spray until injury ceases with nicotine and soap (formula 14, p. 168).

Hop Flea Beetle, *Psylliodes punctulata* Melsh.—A small green or bronze metallic beetle (fig. 96), 1/10 inch long, attacks the foliage. It jumps quickly

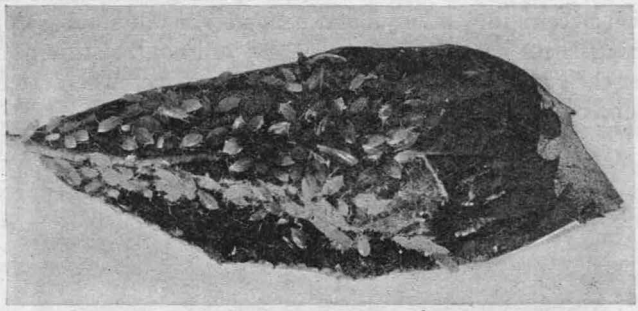


Fig. 95.—The hop aphid, *Phorodon humuli* (Schr.), on the underside of a plum leaf. From the plum and prune it migrates to hops.

when disturbed. The most efficient method of control consists in putting sticky bands around the bases of the vines and around the poles. These not only prevent the beetles from climbing the vines but also catch great numbers of them. Dusting with fluosilicate compounds or calcium arsenate is also effective.

Fig. 96.—The adults of the hop flea beetle, *Psylliodes punctulata* Melsh. (About four times natural size.)

IRIS

Tulip Bulb or Iris Root Aphid, *Aphis tulipae* (B. d. F.).—A pale-green or whitish aphid covered with fine whitish powder infests the stalks, bases of the leaves, the crowns, and the bulbs of irises and also of tulips and gladiolus. Use summer-oil and nicotine sprays (formula 13, p. 168) in the

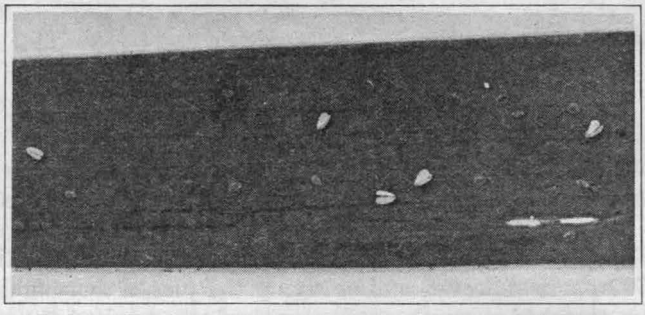


Fig. 97.—The iris whitefly, *Aleyrodes spiraeoides* Quaint., on an iris leaf. The immature forms are scalelike and fixed to the leaf. The tiny adults are covered with white powdery wax.

garden, and fumigate infested bulbs with nicotine or cyanide dust before planting.

Iris Whitefly, *Aleyrodes spiraeoides* Quaint.—The immature forms of this insect somewhat resemble soft scales, being oval, flat, and about 1/8 inch in

length. They are often crowded in immense numbers on the leaves of the plants in late summer and fall. The adults (fig. 97) appear as exceedingly minute, white, four-winged insects, often suggesting tiny moths. As the insects do not become abundant and destructive until late in the year, control is hardly necessary. Cutting the leaves will kill great numbers. Spraying with combinations of oil and nicotine (formula 13, p. 168) or pyrethrum and oil (formula 18, p. 172) will also kill the immature forms.

KALE

(See "Cabbage," p. 37)

LAWNS

Earthworms.—Earthworms, or angleworms, frequently cover golf greens with casts of earth, which are undesirable in such a place. To cause the worms to come to the surface, apply mercuric chloride, mixed as follows, and then sweep up the worms and remove them:

Mercuric chloride (corrosive sublimate)	1 pound
Boiling water	1 gallon

Let cool for 1 hour; then add 4 gallons of cold water. Use 2½ pints of this solution to a barrel of water (50 gallons), and apply to greens with a sprinkler. Or formula 8 (p. 162) may be modified to ¼ ounce mercuric chloride and 8 gallons water. See page 162 for precautions in the use of mercuric chloride. This is a dangerous poison.

Satisfactory results have also been obtained by dusting the lawns with powdered lead arsenate at the rate of 1 pound per 100 square feet and then watering it in. The worms ingest the poison with the surface soil and are killed.

Sod Webworms or Lawn Moths, *Crambus bonifatellus* (Hulst) **and** *C. sperryellus* Klots.—These are small, fawn-colored or silver-striped moths that fly slowly over lawns at dusk while scattering eggs in the grass. The worms cause considerable injury in summer and early fall to new bent and bluegrass lawns. The worms are grayish and black-spotted, about ⅔ inch long when full grown. They feed on the crown and new buds, and cause irregular brown spots in the lawn. They may be controlled by applying a spray of standard lead arsenate, 5 pounds per 50 gallons of water per 1,000 square feet, preferably applying with sprinkling can. The spray should be allowed to dry before rewatering. It may be necessary to repeat the application after 6 weeks.

LEEK

(See "Onion, Garlic, Leek, Shallot," p. 92)

LEMON

(See "Citrus Fruits," p. 50)

LETTUCE

Millipeds.—Millipeds are slow-moving, brownish, cylindrical worms, which fold up like a watch spring when disturbed. They are often abundant in heavily manured soils or those rich in humus and in such cases may do considerable damage to succulent plants. Drying out the soils and reducing the

favorable breeding places aid in control. Applications of lead arsenate (1 pound to 1,000 square feet of soil) and raking or spading it in will kill many of these pests. Applications of commercial fertilizers also seem to be unfavorable to their development.

Hyaline Grass Bug, *Corizus hyalinus* (Fab.), **and Other Species.**—The grass bugs are pubescent, brownish, ¼ inch long, with clear membrane and black markings. They are common on wild lettuce (*Lactuca* sp.), Indian mallow (*Abutilon* sp.), alkali mallow (*Sida* sp.), and other weeds, from which they migrate to truck and garden crops. They hibernate as adults in fields or in houses, where their presence is often annoying, although they cause no real damage there. Eggs are deposited on their food plants in the spring, and four or five generations follow at monthly intervals throughout the season. Damage is usually slight but becomes severe on lettuce grown for seed. Control is best accomplished by clean culture and by burning neighboring weed fields to prevent a buildup in population of the bugs.

Beet Aphid.—See under "Beet" (p. 29).

Transverse Poplar Gall Aphid, *Pemphigus populi-transversus* Riley.—The wingless forms occurring on the roots of lettuce are pale yellowish or greenish and the bodies covered with fine cottony wax or powder. The winged forms are pale and black. This aphid migrates from poplars and cottonwood, where it forms stem galls on the leaves during the summer (fig. 98), to roots on lettuce and cabbage and possibly other related plants. This aphid was long thought to infest lettuce roots but it appears likely that the beet aphid is the common pest on these roots.

Fig. 98.—Galls of the transverse poplar gall aphid, *Pemphigus populi-transversus* Riley, on the petioles of cottonwood leaves. The aphids from such galls may migrate to lettuce fields.

Green Peach Aphid, *Myzus persicae* (Sulzer), **and Other Aphids.**—Aphids can be most satisfactorily controlled on the small plants when infestations first appear. For control, apply a 4 per cent nicotine dust at the rate of 25 to 35 pounds to the acre. See under "Bulbs" (p. 33).

Armyworms and Cutworms.—See under "Alfalfa" (p. 4); see also page 144.

Corn Earworm, or Tomato Fruitworm, *Heliothis armigera* (Hbn.).—Caterpillars of this well-known moth often cause considerable losses to lettuce in the fall when they bore into the center of the heads. Dusting with a 40 per cent cryolite dust (40 per cent cryolite and 60 per cent talc or other diluent) offers some control if applied when the caterpillars first appear and prior to the time they burrow into the heads. In order to avoid poisonous residues, cryolite should not be applied after the heads begin to form. For a description of the insect, see under "Corn" (p. 56).

Alfalfa Semilooper, *Autographa californica* (Speyer).—During the spring and summer, the green caterpillars of this cutworm moth are found on lettuce, often causing considerable injury. Dust with a 33 to 40 per cent cryolite dust (see "Corn Earworm") after thinning when the small caterpillars appear, at the rate of 30 pounds to the acre. After the heads form, a pyrethrum dust containing 0.10 per cent pyrethrins, or cube or derris dust containing 0.75 per cent rotenone should be used.

LILY

Lily Thrips, *Liothrips vaneeckei* Pr.—Adults are shiny black, 1/16 inch long while the larvae are salmon pink with black markings. They feed on the bulbs in the soil and in storage. Control consists in fumigating bulbs in storage with paradichlorobenzene (PDB) at the rate of 3 ounces per cubic foot of space for 96 hours at 58° F or up to 70°.

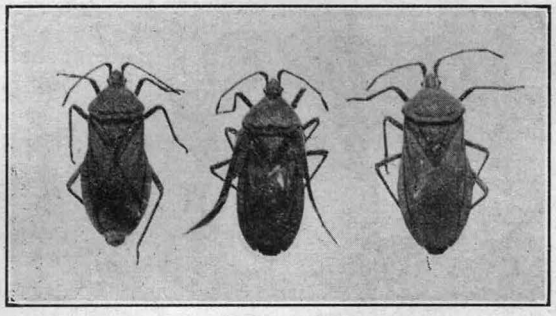


Fig. 99.—The squash bug, *Anasa tristis* (DeG.). (About one and one-half times natural size.)

Lily Aphid, *Myzus circumflexus* (Buck.).—This aphid is a small pale-yellow species often with black markings on the dorsum of the apterous female and with black head, thorax, and abdominal markings on the winged forms. It may be a very serious pest of lilies. For control spray with nicotine and soap (formula 16, p. 171).

LOQUAT

Green Apple Aphid.—See under "Apple and Quince" (p. 9).

San Jose Scale.—See under "Apple and Quince" (p. 11).

MELONS (CANTALOUPE, CASABA, GOURD, PUMPKIN, SQUASH, WATERMELON)

Nematode.—See page 136.

Flower or Grass Thrips.—See under "Peach and Nectarine" (p. 95).

Squash Bug, *Anasa tristis* (DeG.).—The adults (fig. 99) are flat-backed grayish-brown bugs about 3/4 inch long. The nymphs are shorter, grayish, and more oval. The small, shining, brown eggs are laid fully exposed on stems and leaves. Injury consists of wilting and eventual drying up of leaves and runners. Eggs are laid in the spring, and the nymphs require about 2 months to reach maturity. There is only one generation each year, the adults feeding through the season and then hibernating until the following spring.

Control should be directed at the hibernating forms by cleaning up the old vines and other hiding places, by trapping adults beneath boards at night and destroying them in the early morning, and finally by spraying the susceptible nymphs with nicotine and oil (formula 13, p. 168), pyrethrum and oil (formula 18, p. 172), or rotenone and oil (commercial products). If spraying is repeated three times at 10-day intervals, the bugs may be eliminated. In small gardens this bug may be kept under control by hand-picking the eggs and the young and adults.

Cotton or Melon Aphid, *Aphis gossypii* Glover.—A small, very dark-green aphid occurs in great numbers on the plants and does great damage. It transmits melon mosaic (fig. 100), which causes stunted and deformed plants with mottled yellow and green leaves. Destroy the first plants infested with the aphid as soon as discovered in spring, or spray with 1 part of 40 per cent nicotine sulfate to 1,000 parts of water. A 4 per cent commercial nicotine dust (see p. 171), applied at the rate of 15 to 25 pounds per acre, also gives very good results and is much more easily and quickly applied. Pyrethrum and rotenone sprays are effective if thoroughly applied to the under surfaces of the leaves.

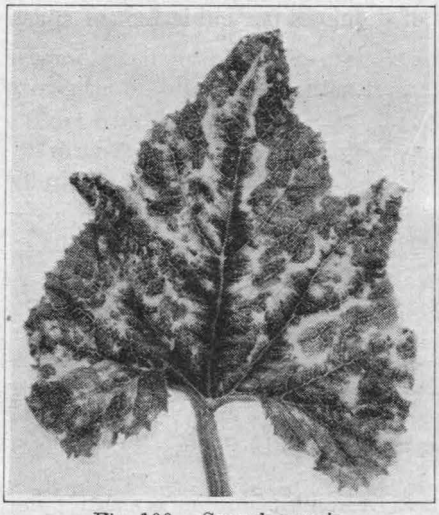


Fig. 100.—Squash mosaic. (From Ext. Cir. 119.)

Western Spotted Cucumber Beetle, *Diabrotica 11-punctata* Mann.—This common small green beetle with twelve black spots on the back (fig. 101) is often mistaken for a ladybird. The white larvae feed upon the roots of many different kinds of plants and may be controlled by pouring on the roots a cup of 40 per cent nicotine sulfate diluted 1 to 1,000 parts with water. The adults feed on a wide variety of plants, attacking principally the leaves and flowers, although they may eat the epidermis from stems. When a residue problem is not involved, they can best be controlled by thoroughly dusting the plants with a dust composed of 50 per cent cryolite and 50 per cent talc or with undiluted commercial calcium arsenate. For good control the dust should be evenly and thoroughly applied. Where seedlings are being attacked, the dust should be applied extra heavily. Where there is a residue problem or where aphids or leafhoppers are also involved, a contact insecticide can be used. For example, a dust containing finely ground pyrethrum flowers (pyrethrins 0.1 or 0.2 per cent) and 2 per cent of Lethane 384 in talc or a 5 per cent Pyrocide dust applied at the rate of from 25 to 40 pounds per acre should effectively control the pest. Plants should be thoroughly covered with the dust when they are dry and the temperature not higher than 65° F. The dust drift should be away from the undusted portion of the field. A pyrethrum dust will not prove effective if the plants are wet.

MILLET

(See "Grain," p. 71)

MUSHROOMS

Mushroom growing is a highly specialized industry, which must take into consideration the elimination and control of pests from the very beginning. The sterilization of the compost and the spawn is of prime importance, and

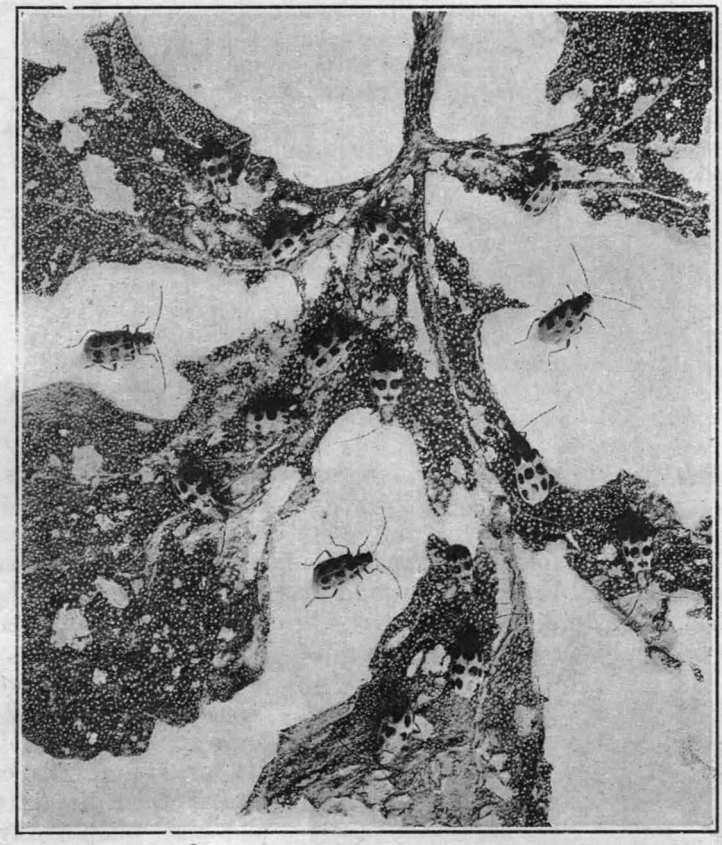


Fig. 101.—The western spotted cucumber beetle, or diabrotica, *Diabrotica 11-punctata* Mann., and its work on leaves of watermelon. (4 times natural size.)

will prevent the establishment of most of the mites and insects which may spell ruin in the industry. The screening of doors, windows, and ventilators with fine wire gauze and adequate equipment for heating may add much to the success of the undertaking.

Mushroom Mite, *Tyroglyphus lintneri* Osb.—This mite (fig. 102) is perhaps the commonest and most serious pest. It is a minute, transparently white, somewhat hairy, soft-bodied creature, which moves slowly and awkwardly through the beds. It attacks the mushrooms in all stages and causes serious

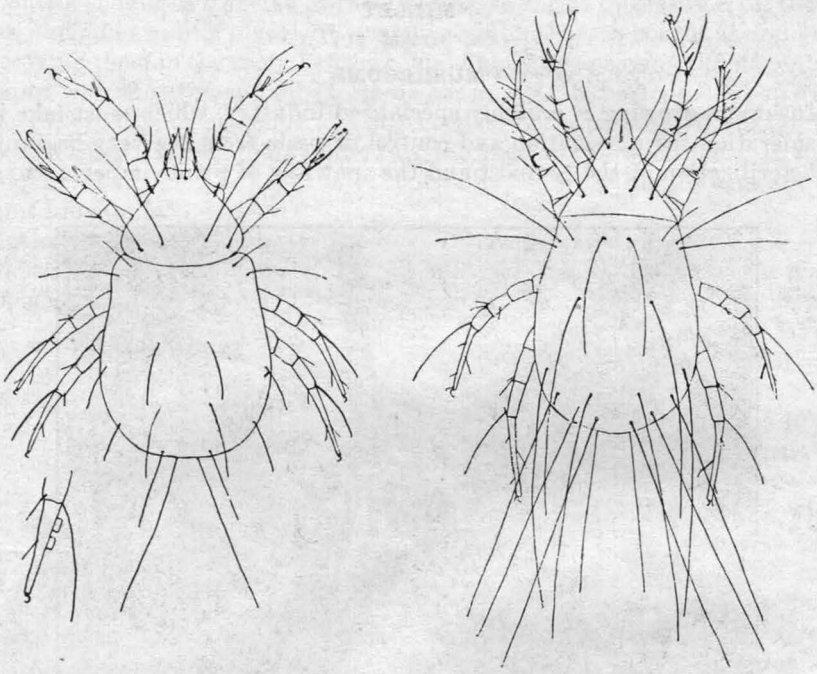


Fig. 102.—The mushroom mite, *Tyroglyphus lintneri* Osb. (Very greatly enlarged.) (After deOng and Roadhouse.)

damage or almost complete loss. Prevention is the only satisfactory cure. Infested houses should be cleaned out and thoroughly disinfected. When once established, it is most difficult to control. The use of carbon disulfide emulsion gives, at best, only temporary relief.

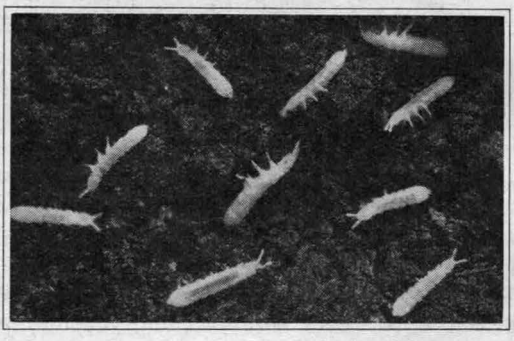


Fig. 103.—The seed springtail, *Onychiurus pseudarmatus* Folsom. This minute white insect lives in the soil and feeds on planted seeds, tender rootlets, mushrooms, and other fungi. (About ten times natural size.)

Springtails, *Achorutes* spp., *Onychiurus* spp., and *Entomobrya* spp. — Springtails (fig. 103) are minute white or dusky insects which live in the soil and may jump freely. They feed extensively on fleshy fungi and may often occur in considerable numbers in mushroom houses. As they often congregate near the surface of the beds, they may be killed by fumigating the houses with calcium cyanide dust at the rate of 2½ ounces per 1,000 cubic feet. Placing cheap muslin over the infested beds and then sprinkling paradichlorobenzene rather thickly over the cloth, covering the whole with paper to prevent the upward

escape of the gas, and allowing the fumigant to remain for a period of 48 hours, has also been successful in eastern houses.

Mushroom Maggots, *Sciara* spp., **and** *Aphiochaeta* spp.—These insects are serious pests of cultivated mushrooms, the small white maggots, or larvae, and the black gnatlike flies, or midges, the adults, fairly swarming in the mushroom houses. Here again clean compost and spawn are essential. The adults may be easily killed by frequent fumigations with nicotine smudges, and this of course eventually eliminates the larvae.

MUSTARD

(See "Cabbage," p. 37)

NASTURTIUM

Bean Aphid and Green Peach Aphid.—See under "Bean" (p. 25) and "Spinach" (p. 112).

NECTARINE

(See "Peach and Nectarine," p. 95)

NUTS IN STORAGE

(See "Dried Fruits," p. 65, and "Stored Cereals and Beans," p. 114)

Indian-Meal Moth, and Mediterranean Flour Moth.—See under "Dried Fruits" (p. 65).

Saw-toothed Grain Beetle, *Oryzaephilus surinamensis* (Linn.), **the Cadelle,** *Tenebrioides mauritanicus* (Linn.), **the Confused Flour Beetle,** *Tribolium confusum* Duv., **and the Rusty Flour Beetle,** *T. ferrugineum* (Fab.).—For descriptions, see under "Stored Cereals and Beans" (p. 114). For control, store nuts in clean, tight containers. Where small amounts are infested, use carbon disulfide as recommended for the control of stored cereals (p. 117).

In warehouses, or where large quantities of nuts are infested, methyl bromide is a very effective fumigant. It does not noticeably affect the germination quality of seeds. For insured success it is necessary to have a tight chamber and preferable to carry on the fumigation at a temperature of 60° F or higher. Under these conditions, methyl bromide should be used at the rate of 1 pound per 1,000 cubic feet of chamber space. The length of exposure to obtain satisfactory control is somewhat dependent upon temperature. With high temperatures the minimum exposure should be at least 12 hours, but, where possible, the period should be increased to 24 hours. At temperatures below 70° F, the length of exposure should always be at least 24 hours. At the close of the fumigation period, it is necessary to open up the chamber and allow it to ventilate before entering. Methyl bromide settles very rapidly and if there is any circulation at all, the chamber should be free of the gas within 5 to 10 hours, provided the ventilating opening extends to the floor.

Methyl bromide is obtainable in cylinders, 1-pound cans, and ½-pound cans. It is easily applied from these containers. The cylinders, which contain 50 pounds of methyl bromide, can be fitted with applicators for measuring dosages. It is likely, however, that most farmers would find it more to their advantage to use 1-pound cans. Simple and effective applicators for applying

the material from the 1-pound cans are available. Directions for their use can be obtained from the manufacturers and should be carefully followed. If an applicator is used, the fumigation chamber can be tightly sealed and the methyl bromide applied from the outside. A fitting may be placed in the wall of the chamber, into which the applicator is screwed. The fumigant should be applied on top of the material to be fumigated and if possible in the center of the chamber. If the chamber is large, the methyl bromide may be delivered to the center by means of a copper tubing or rubber hose attached to the delivery end of the tube that leads from the applicator. As a word of caution, it should be stated that cans of methyl bromide should always be held so that there will be no danger that the material will squirt out on the person handling it. Also, the hole punched in the end of the can should be at the lowest point, so all the liquid will drain out of it. Methyl bromide is under pressure in the can and is expelled with considerable force. Read carefully the directions given on the label. After the application a warning sign should be placed on the door of the chamber.

Where infested material is in sacks, and no fumigation chambers are available, rubberized tarpaulins or ones otherwise treated to make them gastight can be used. The product should be stacked on a good tight floor or smooth bare ground and covered with a tarpaulin which should be large enough so that there is a 2-foot strip that lies on the floor. This strip should be tightly sealed to the floor about the stack with weights. The height of the stacked material should not be more than 6 feet and so arranged that when the tarpaulin is put over it there will be a dome or head space on top of the pile to serve as an expansion chamber for the gas and to allow for its circulation. This can best be done by placing two sacks on edge about 4 feet apart. The methyl bromide should be liberated at the top and center of the stack. It can be delivered from the applicator to this point by means of a rubber tube. If possible, the end of the tube should be so directed that the methyl bromide will not be sprayed directly on the tarpaulin, because it is somewhat injurious to the rubberized material. After injection the rubber tube should be removed.

OAK

Red Spiders.—Several species of red spiders, or mites, attack the foliage of oak trees and cause leaves to turn gray and brown and to fall prematurely. Control may be accomplished by spraying with highly refined oils.

Woolly Oak Aphid, *Stegophylla quercifoliae* (Gill.).—This woolly aphid rolls the edges of the leaves of live-oak trees, a habit which makes it very difficult to control. Spray with oil and nicotine (formula 13, p. 168), nicotine and soap (formula 16, p. 171), or pyrethrum and oil (formula 18, p. 172).

Cloudy-winged Oak Aphids, *Myzocallis bellus* (Walsh) **and** *M. californicus* (Baker).—These are small green or yellow aphids living and feeding on the undersides of the leaves of many kinds of oaks. They are readily killed by using soap (p. 173), oil and nicotine (formula 13, p. 168), or pyrethrum and oil (formula 18, p. 172) sprays.

Pit-making Oak Scales, *Asterolecanium minus* Lind., **and** *A. quercicola* (Bouché).—The first species occurs on valley oak and the other on introduced red oak. They are small greenish beadlike scales, often partly embedded in a

pit in the bark of the twigs (fig. 104). In some sections these scales do considerable damage to the hosts and may kill the twigs or even the tree. Control consists in spraying with 4 per cent medium oil emulsion during the dormant season.

California Oak Moth, *Phryganidia californica* Pack.—The adult is a small pale-brown moth nearly 1 inch long. The somewhat flattened, globular white eggs are laid in masses on the leaves, limbs, and trunks of the trees in the fall of the year and again in summer—there are two broods a season. The caterpillars feed upon the leaves and may appear in such great numbers, especially in late summer, as to completely defoliate the oak trees. Pupation occurs on the trees or on any nearby objects. Control measures should be particularly directed against the first-brood larvae in April and May; but if neglected, the sprays should be applied as soon as the damage to the foliage is noted. Spray thoroughly with lead arsenate at the rate of 3 pounds of the powder to

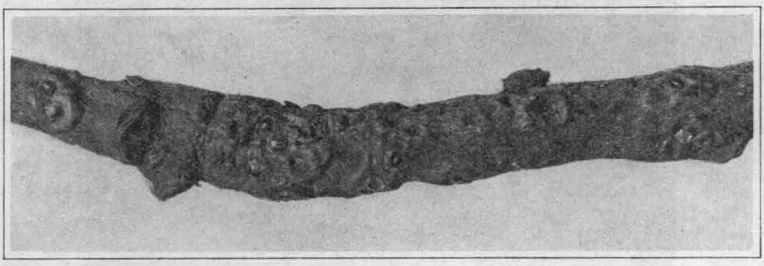


Fig. 104.—The pit-making oak scale, *Asterolecanium quercicola* (Bouché), and pits produced by it on oak twigs.

100 gallons of water. The addition of ½ pint of fish oil, as an adhesive, will add to the effectiveness of the spray in making it more resistant to rains.

Oak Twig Girdler, *Agrilus angelicus* Horn.—The larva of this beetle bores in the bark of small branches of live oaks and causes clumps of dead, brown foliage. The beetles emerge during May and June. Control can be obtained by cutting out and burning the infested clumps during the winter months or in early spring before the beetles emerge.

Gallflies or Cynipids.—These small, mostly brownish or black antlike insects lay their eggs in the tissues of the trees. The larvae develop in the roots, twigs, leaves, blossoms, and acorns and in most cases cause swellings of roots and twigs or conspicuous galls of various sizes, shapes, and colors on the twigs, leaves, and flowers. These galls are often deciduous and drop to the ground in late summer and fall. The larvae or pupae hibernate in the galls. Control measures are extremely unsatisfactory and consist in raking up and burning the galls in the fall or in cutting out and burning the infested portions of the tree. Ordinarily these gallflies do not seem to injure the trees seriously unless the latter are growing under very unfavorable conditions.

OATS

(See "Grain," p. 71)

OLIVE[27]

Black Scale, *Saissetia oleae* (Bern.).—This scale attacks twigs and smaller branches of olive trees. For control, spray with light-medium oil in August or September, or fumigate with cyanide. See under "Apricot" (p. 15) and "Citrus Fruits" (p. 53) for description.

Fig. 105.—The olive scale, *Parlatoria oleae* (Colvée), on ripening fruits. The areas around the scales turn deep reddish maroon.

Olive Scale, *Parlatoria oleae* (Colvée).—This scale, purple-bodied beneath a dirty-white covering, occurs generally only in Fresno and adjoining counties. The females are small and circular; the males usually present in large numbers are smaller and elongate. Both sexes occur on trunks, twigs, leaves, and fruit and cause dark spots on green olives (fig. 105). Control by tent fumigation with hydrocyanic acid gas preferably after harvest and before fruit buds start to grow, or spray with heavy-medium summer oil 3 per cent

[27] For further details see: Essig, E. O. The olive insects of California. California Agr. Exp. Sta. Bul. 283:41–64. 1917. (This bulletin is out of print but may be consulted in many city and county libraries in California.)

in February and March. Heavily infested trees should be sprayed again in late June or early July with 2 per cent oil.

Ivy or Oleander Scale, *Aspidiotus hederae* (Vall.).—A yellow-bodied scale beneath a small, circular, flat, gray covering occurs on leaves (fig. 106) and

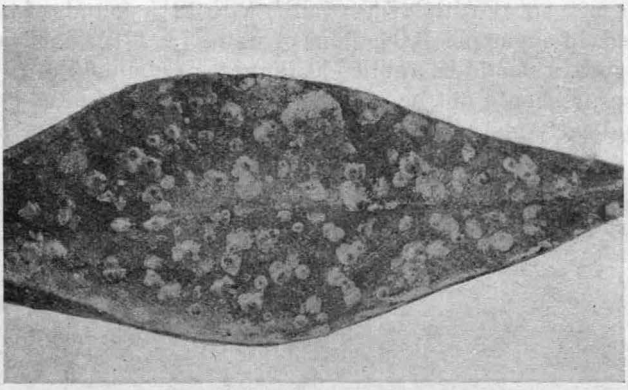


Fig. 106.—The ivy or oleander scale, *Aspidiotus hederae* (Vall.), on olive leaf.

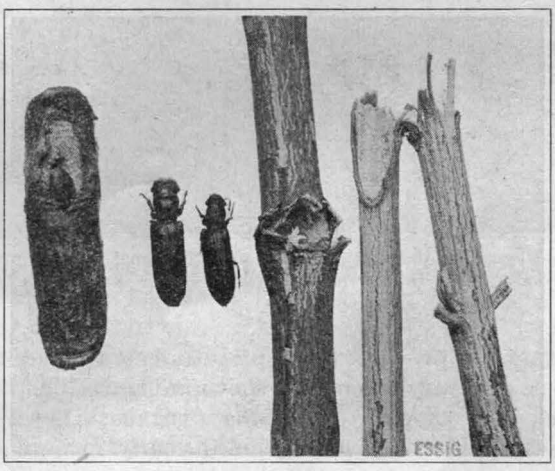


Fig. 107.—The branch and twig borer, *Polycaon confertus* Lec., and its work on small limbs of olive trees. The larvae live in dead dry wood.

fruit. The part of the olive around the scale fails to ripen and is often deformed. Control as for olive scale.

Red Scale, *Aonidiella aurantii* (Mask.).—For description, see under "Citrus Fruits" (p. 54). Red scale occasionally attacks olive twigs and fruit, sometimes preferring the fruit. Control, rarely needed, is by cyanide fumigation if possible.

Branch and Twig Borer, *Polycaon confertus* Lec.—This is often a serious pest of young olive trees (fig. 107). See under "Apricot" (p. 16).

ONION, GARLIC, LEEK, SHALLOT

Onion Thrips, *Thrips tabaci* Lind.—The grayish-brown adult and the yellow-white larvae feed together in the growing points and on the smaller leaves and produce a withered appearance. Good control can be obtained by spraying (using a fine mist spray with low pressure) with 12½ pounds of tartar emetic and 25 pounds of sugar per 100 gallons of water (p. 176). Such concentrated poison-bait sprays should be applied at the rate of about 15 to 20 gallons per acre. This spray should not be applied to plants to be sold as green onions. Resistant and early-maturing varieties should be planted where possible.

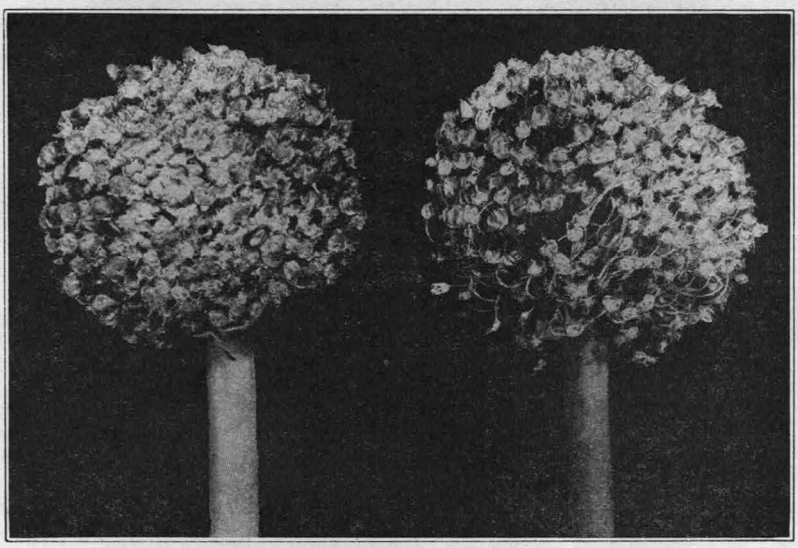


Fig. 108.—Flower-thrips injury to onion seed. The small, white florets are those that have been killed by the thrips. As high as 50 per cent loss in the seed crop often occurs in this way. (From Cir. 346.)

Flower or Grass Thrips.—For description and control, see under "Peach" (p. 95). The type of injury on onion is shown in figure 108.

Onion Aphid, *Micromyzus formosanus* (Takahashi).—A shining, very dark-red or black aphid infests the tops in the early-spring months and may be present in such numbers as to kill the plants. It may be introduced with plants or sets, on which it is able to survive the winter in storage. So far it has been a pest only in small gardens. For control use 2 per cent nicotine dusts or nicotine sulfate spray (formula 16, p. 171).

Armyworms and Cutworms.—See page 144.

Onion Maggot, *Hylemya antiqua* (Meigen).—Small, white maggots attack the onions beneath the ground. Practice clean culture and destroy all refuse onions in the fall. Plow and cultivate thoroughly during winter and spring. For control use mercuric chloride or mercurous chloride (calomel) as recommended for cabbage maggot (see under "Cabbage," p. 39). For large acreages grown for "sets," spraying with a bordeaux mixture and oil emulsion gives an effective control. To 97 gallons of a 16–12–100 bordeaux mixture

(mixed as in formula 4, p. 158), add 3 gallons of a lubricating oil emulsion, and mix. Several applications at weekly intervals at the rate of from 100 to 125 gallons per acre are necessary.

ORANGE

(See "Citrus," p. 50)

PALMS

(See "Date," p. 64)

PARSLEY AND PARSNIP

Western Parsley Caterpillar, *Papilio zelicaon* Lucas.—The large, green, black, and orange caterpillars are well known to most gardeners. In addition to feeding on wild members of the parsley family, they feed on parsley, carrots, celery, and parsnips. Pyrethrum (formula 18, p. 172) or commercial rotenone sprays and dusts will assist in controlling these caterpillars; or, if only a few plants are involved, hand-picking will suffice. See under "Celery" (p. 45).

Celery or Greenhouse Leaftier.—See under "Celery" (p. 45).

PEA

(See "Stored Cereals and Beans," p. 114)

Garden Centipede.—See under "Snapdragon" (p. 111).

Two-spotted Mite.—See under "Bean" (p. 23).

Western Plant Bug or Cotton Dauber, *Lygus hesperus* Knight, **and Alfalfa Plant Bug,** *L. elisus* V. D.—See under "Alfalfa" (p. 3).

Pea Aphid, *Macrosiphum onobrachis* (B. d. F.) (*M. pisi* Kalt.).—This large green aphid, which attacks many legumes, infests the terminal shoots of the pea vines and is often difficult to control. Dust when the aphids first appear with one of the following: a 4 per cent commercial nicotine dust; a nicotine and sulfur dust containing 4 per cent nicotine and 40 per cent dusting sulfur, the rest hydrated lime, a mixture which may also serve to control mildew; a cube and pyrethrum dust containing 0.5 per cent rotenone and 0.1 per cent pyrethrins; or a rotenone dust containing 0.75 per cent commercial rotenone, to which is added 4 per cent of a vegetable or animal oil. The amount of material needed may vary from 25 to 40 pounds per acre according to the method of application and the size of the vines. Repeated applications may be necessary. Commercial rotenone or rotenone and pyrethrum sprays are effective, espe-

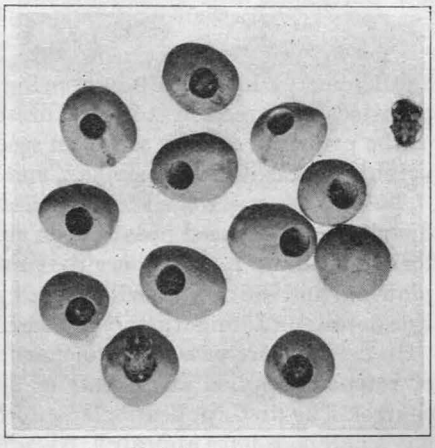


Fig. 109.—Dried garden peas showing the exit holes of and adults of the pea weevil. The larvae matured within the seeds.

cially for peas on trellises when suitable wetting agents are added. See also under "Alfalfa" (p. 3).

Armyworms and Cutworms.—See page 144.

Alfalfa Caterpillar, *Colias eurytheme* Bdv.—See description and control under "Alfalfa" (p. 5). The young caterpillars are often very destructive to garden and sweet peas.

Pea Weevil, *Laria pisorum* (Linn.).—This is a small grayish or brownish-gray weevil about ⅕ inch long, marked with black, gray, and white patches. The eggs are laid on the young pea pods. On hatching the larvae enter the pods and work their way into the peas, where development is completed. The

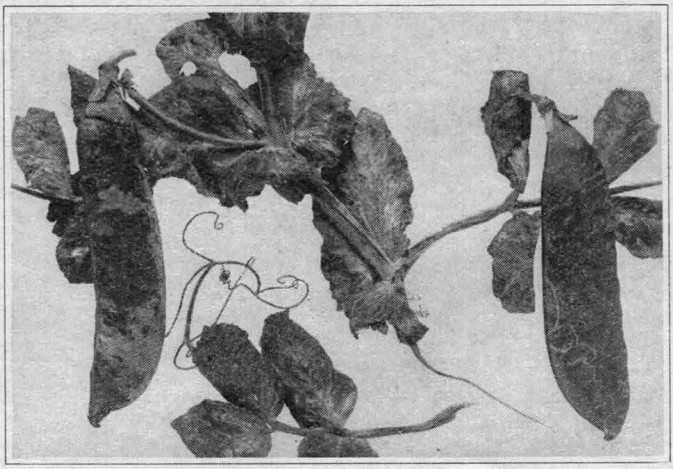


Fig. 110.—The serpentine leaf miner, *Agromyza pusilla* Meigen. Mines are visible on stems, leaves, and pods of green peas.

adults emerge in the fall and spring (fig. 109). Unlike the bean weevil, the pest does not breed in storage. Infestation takes place in the field, and some of the principal sources are from seed peas shattered on the fields at harvest, volunteer peas, weevily pea hay, and weevily pea seed.

To control, use weevil-free seed, avoid growing seed peas in canning-pea districts, harvest seed peas as soon as they ripen in order to reduce field shattering, clean up places where the pest can overwinter, destroy field refuse by plowing, and destroy weevils in seed peas as soon as harvested by fumigation. For details on fumigation, see "Stored Cereals and Beans" (p. 117).

In fields where peas are to be harvested green, a dust containing 1 per cent of rotenone applied at the rate of 20 to 25 pounds per acre has given good control. The first application should be made after the peas bloom but before any small pods have appeared. An additional application or two may be necessary if weevils continue to migrate into the field.

A trap crop of early peas planted around the field borders has been used. The weevils concentrate on these peas when they come into bloom, and can be killed by dusting; or the trap crop may be plowed under or otherwise destroyed as soon as it has gone out of bloom.

Serpentine Leaf Miner, *Agromyza pusilla* Meigen.—The small whitish grubs mine the leaves, stems, and pods of peas and other plants causing slender, white, winding tunnels (fig. 110). In severe infestations the leaves dry up completely and the plants die. Fall peas cannot be profitably grown in certain areas owing to the ravages of this insect. No satisfactory control is known. Frequent dustings with calcium arsenate have proved to be of some value.

PEACH AND NECTARINE

Root-Knot Nematode.—See page 136.

Peach Silver Mite, *Phyllocoptes cornutus* Banks.—A microscopic mite causes a silvering of the leaves. Spray in winter when the trees are dormant or when buds swell in the spring with lime-sulfur, 1–10, to kill mites hibernating in buds.

Two-spotted Mite.—See under "Plum and Prune" (p. 102).

Flower or Grass Thrips,[28] *Frankliniella moultoni* Hood.—The adult of the flower thrips is light yellow to orange brown and the larva is yellow. This insect is found in nearly all buds and blossoms and often scars and deforms small fruit (fig. 111) and newly developed leaves. Application of rotenone sprays after petal fall on peaches and plums prevents fruit scarring. Clean cultivation in and about the orchards for 2 or 3 weeks before blooming aids considerably in reducing injury to nectarines.

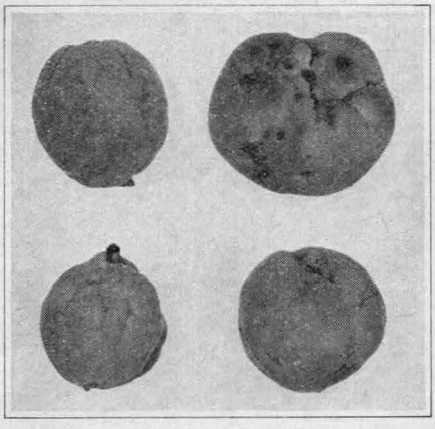


Fig. 111.—Peaches showing injury caused by early attacks of the flower or grass thrips when the fruit was very small.

On field and annual crops, pyrethrum dusts used at 30 pounds per acre, two applications about 10 days apart, with an irrigation between dustings, will give very good control.

In greenhouses and flower gardens, weekly applications of contact sprays (using liquid concentrates to avoid objectionable residue), such as pyrethrum and oil (formula 18, p. 172) commercial rotenone, nicotine sulfate (formula 16, p. 171), or thiocyanate (Lethane at about 1 part to 800 parts of water) are recommended.

Black Peach Aphid, *Aphis persicae-niger* Smith.—A shiny black aphid sometimes occurs in great numbers on the young tender shoots. This insect appears to pass the winter as adults and young on the roots in the colder areas and as immature forms on the new wood in the warmer regions along the coast. Spray with nicotine and soap (formula 16, p. 171) or dust with 2 per cent nicotine dust as soon as the insects appear.

Green Soldier Bug, *Acrosternum hilare* (Say).—This bug is an oval, bright-green species ¾ inch long with the orange-tinged margin of abdomen spotted

[28] Bailey, S. F. Thrips of economic importance in California. California Agr. Exp. Sta. Cir. 346:20–33. 1938.

with black. Hibernation occurs in the adult stage. Eggs are laid in the spring and the species passes through two or more generations during the season, feeding upon a wide variety of native and cultivated plants. Feeding punctures cause scarring and exudation of juices on peaches. For control, practice clean culture in the orchards susceptible to infestation.

Plant Bugs, *Lygus* spp., and Grass Bugs, *Irbisia* spp.—See under "Alfalfa" (p. 3), "Cotton" (p. 58), and "Grains" (p. 71) for detailed life histories. Injury is caused by the feeding punctures and appears as smooth,

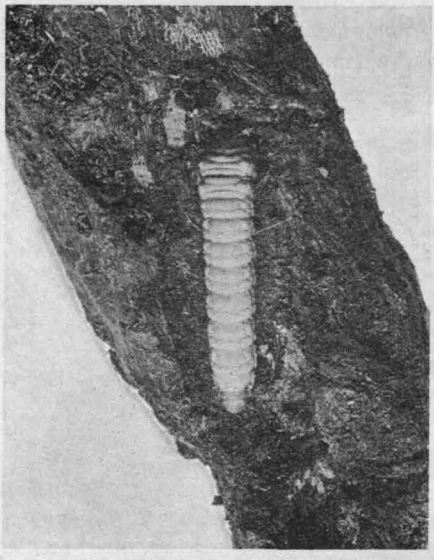


Fig. 112.—The larva of the Pacific peach tree borer, *Conopia opalescens* (Hy. Edw.), exposed to view by removing the bark of the tree. (Enlarged three times.)

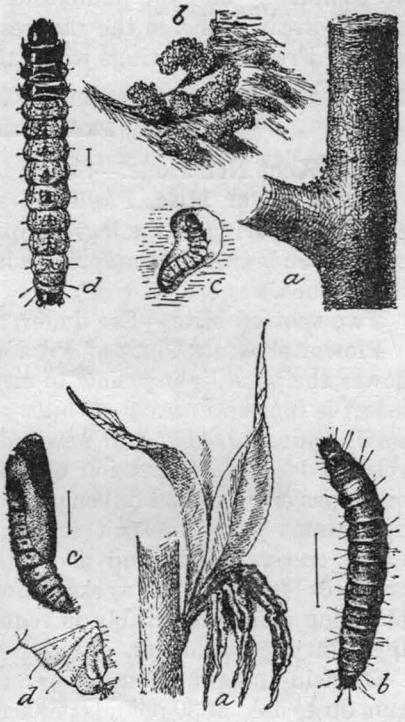


Fig. 113.—The peach twig borer, *Anarsia lineatella* Zell. Top: *a*, limb showing location of the hibernaculae, or winter cells; *b*, chimneys thrown up in constructing the hibernaculae, enlarged; *c*, larva in the hibernacula; *d*, larva, enlarged. Bottom: *a*, young spring shoot killed by the larva; *b*, larva; *c*, pupa; *d*, posterior tip of pupa. (Lines show natural sizes.) (After Marlatt, United States Department of Agriculture.)

sunken areas if the feeding is done early, or as hard, darkened areas with or without a drop of sticky exudation if done when the fruit is nearly ripe. Control should be directed at the bugs on their normal weed or grass hosts or on the covercrops. These weeds should be plowed under before the bugs build up in numbers. Greatest damage is caused by the drying up of the weeds or cutting of alfalfa during development of the fruit, which forces the bugs to feed on the fruit.

Brown Apricot Scale.—See under "Apricot" (p. 15).

San Jose Scale.—See under "Apple and Quince" (p. 11).

Olive Scale.—See under "Olive" (p. 90).

Tent Caterpillars.—See page 147.

Cankerworms.—See page 148.

Pacific Peach Tree Borer, *Conopia opalescens* (Hy. Edw.).—The white larvae (fig. 112), attaining a length of 1½ inches, burrow under the bark at the base of the trees and often extend their tunnels down into the bases of the main roots. They are often serious, and may completely girdle the trees. Dig out the worms carefully in the fall and spring and paint over the wounds with a good asphaltum paint. Use paradichlorobenzene in summer and fall (see p. 169).

Peach Twig Borer, *Anarsia lineatella* Zell.—A small, reddish-brown larva (fig. 113), scarcely ½ inch long, burrows into and kills the young, tender

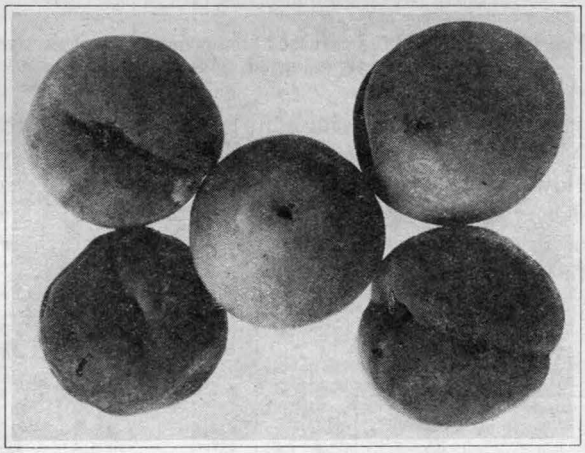


Fig. 114.—The work of the larvae of the peach twig borer on late cling peaches. The burrows are often very small and concealed by frass.

tips of the twigs (fig. 113) and, later in the season, infests the fruit (fig. 114). The tiny, young larvae hibernate in small cells in the bark. The small, slender, gray moth, the adult stage, is seldom seen.

Over a period of years, this pest has been satisfactorily controlled by two applications of 3 to 4 pounds of basic lead arsenate (with ¼ to ⅓ pound of spreader) per 100 gallons of water; the first spray being applied in the early jacket stage (after petal fall), and the second in May, between May 5 and May 20, according to the appearance of the first wilted shoots. In the northern San Joaquin Valley, the worms become active earlier and therefore earlier applications may be more effective. No spraying, however, should be done during full bloom. The basic lead arsenate may be combined with lime-sulfur or bordeaux mixture.

The two applications are also recommended for plums and prunes. On almonds the May spray appears to be particularly effective. On apricots the earlier spray alone (either in the red-bud or jacket stage) is sufficient to check the infestation.

During the summer, infestations of the so-called "stem worms" on peaches may be fairly well controlled by the use of a dust of 70 per cent sulfur and 30

per cent basic lead arsenate. To obtain satisfactory coverage with such a dust, about 40 to 50 pounds of dust per acre should be applied under ideal conditions.

Oriental Fruit Moth, *Grapholitha molesta* (Busck).—A close relative of the codling moth, this insect may be confused with the latter in general appearance. The caterpillars infest the twigs and fruit somewhat after the manner of

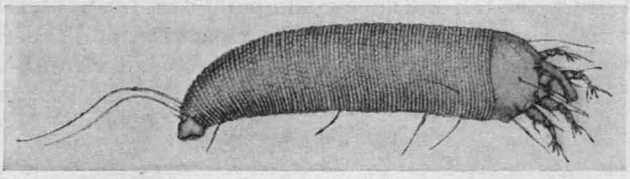


Fig. 115.—Adult of the pear leaf blister mite, *Eriophyes pyri* (Pagen.), greatly enlarged. (After Parrott.)

the peach twig borer. It is an Asiatic species introduced into Washington, D. C., prior to 1916, and has become a pest of considerable importance in the eastern and midwestern states. It appeared in southern California in October, 1942, and has been taken as far north as Sutter County. Since an effective practical control of this insect has not yet been developed, steps are being taken to study its life history and control within this state.

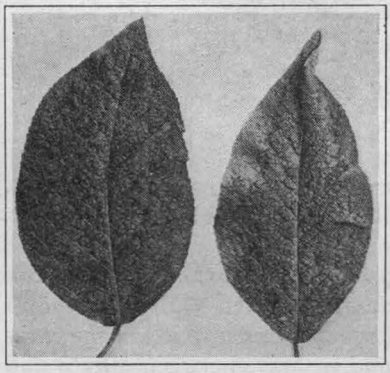


Fig. 116.—Young pear leaves showing blisters produced by the pear leaf blister mite, *Eriophyes pyri* (Pagen.). These blisters vary in color from pale green to yellow or pinkish.

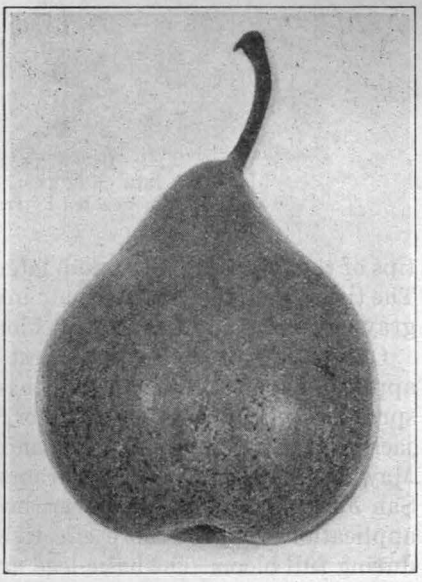


Fig. 117.—Bean-thrips injury to pear fruit. Note speckling on the lower half of the fruit, caused by surface feeding and deposition of excrement. (From Bul. 609.)

Branch and Twig Borer.—See under "Apricot" (p. 16).
Western Flat-headed Borer.—See under "Apple and Quince" (p. 15).
Shot-Hole Borer.—See under "Apricot" (p. 16).

PEAR

Pear Leaf Blister Mite, or Bud Mite,[29] *Eriophyes pyri* (Pagen.).—This microscopic mite (fig. 115) causes pinkish and yellowish blisters or marks on the young terminal leaves (fig. 116) and occasionally reddish blotches on the young fruit. Spray in the fall as soon as the crop is off with a combination of 2 gallons of oil emulsion (viscosity 65 to 70 and unsulfonated residue 90 or above) and 5 gallons of commercial lime-sulfur per 100 gallons of water, to kill the mites before they hibernate in buds. If spring control is practiced, a 2 per cent commercial lime-sulfur spray, with 4 pounds wettable sulfur per 100 gallons of spray, applied in the cluster-bud period will greatly reduce the number of mites and assist in scab control. Four pounds of wettable sulfur

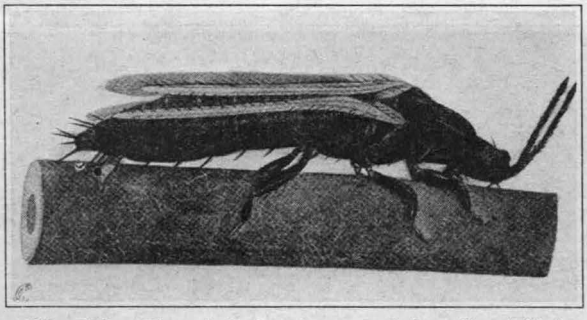


Fig. 118.—The adult female pear thrips, *Taeniothrips inconsequens* (Uzel), showing normal position when ovipositing. (Greatly enlarged.) (Courtesy of Canada Department of Agriculture.)

may also be added per 100 gallons of the first calyx spray of lead arsenate for combined bud-mite and codling-moth control.

Red Spiders.—See under "Apple and Quince" (p. 8).

Bean Thrips, *Hercothrips fasciatus* (Perg.).—When this species appears in destructive numbers, especially on the fruit (fig. 117), spray with a highly refined commercial oil emulsion at 1 per cent concentration, to which is added ½ pint of pyrethrum concentrate (2 per cent pyrethrins) per 100 gallons of the oil emulsion. See under "Bean" (p. 24).

Pear Thrips,[30] *Taeniothrips inconsequens* (Uzel).—The small, dark-brown, winged thrips (fig. 118) attack the buds before blossoming. The white larvae scar and deform the small fruit after petal fall. Derris powder, 2 to 5 pounds per 100 gallons of water, according to whether of high or low rotenone content, gives good control of the larvae. Tartar emetic, 2 pounds, with 2 to 4 pounds of sugar per 100 gallons also gives excellent control. These materials may be combined with the first calyx spray. Spraying as soon as the first adults appear in the buds is frequently ineffective.

[29] See: Borden, Arthur D. The pear leaf blister mite as a cause of fruit-bud injury. California Agr. Exp. Sta. Cir. 324:1–8. 1932. (This circular is out of print but may be consulted in many city and county libraries in California.)

Lamiman, J. F. Pear and bud injury and pear leaf blister mite. Jour. Econ. Ent. 32:40–43. 1939.

[30] Bailey, S. F. Thrips of economic importance in California. California Agr. Exp. Sta. Cir. 346:11–20. 1938.

Green Apple Aphid.—See under "Apple and Quince" (p. 9).

Pear Root Aphid, *Eriosoma lanuginosum* (Hartig).—This is a small dark aphid covered with white cottony material and greatly resembling the woolly apple aphid, but it attacks only pear roots. For control see "Woolly Apple Aphid" under "Apple and Quince" (p. 9). Eliminate young stunted trees and replant with healthy ones. The Japanese root is much more resistant to this pest than the French. Use paradichlorobenzene in the fall (see p. 169).

Grape Mealybug, *Pseudococcus bakeri* Essig.—This mealybug is a small, oval, flat insect less than ¼ inch long, covered with white powdery wax and normally having several white, taillike filaments nearly half as long as the body. The egg sacs look like small masses of cotton. The insects occur under the bark, on the underside of limbs, in cracks, wounds, and in the blossom end of

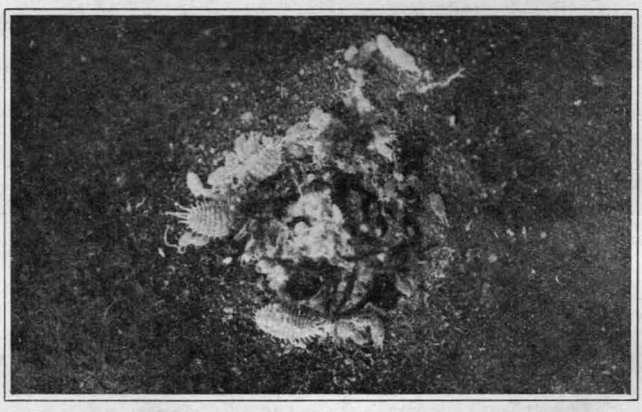


Fig. 119.—The grape mealybug, *Pseudococcus bakeri* Essig, clustered in the blossom end of a pear. (After Essig, *A History of Entomology,* by permission of the Macmillan Co., copyright owners.)

the fruit. Control measures are difficult and consist of repeated applications of 3 per cent emulsive oils or the combination of oil and lime-sulfur (formula 11, p. 167) during the winter months and until the buds begin to open in the spring. Scrape the rough bark from the trunks and larger limbs so as to expose the mealybugs to the spray. If the fruit is infested (fig. 119), spray during the summer with water under heavy pressure to wash the mealybugs away.

Brown Apricot and Other Soft Scales.—See under "Apricot" (p. 15).

Italian Pear Scale, *Epidiaspis leperii* (Sign.) (*E. piricola* [Del G.]).—A small scale with a dark red body beneath a gray, circular covering usually occurs under the moss or old bark; but it may cover the trunks and all of the main branches of the tree. It causes sunken areas in old limbs and greatly weakens the tree. Spray in the winter months, preferably in January and February, with heavy commercial oil emulsions (7 per cent) or with tank-mix oil sprays or emulsive oils, using the heavier oils at 4 per cent. Thoroughly drench the limbs and trunks.

San Jose Scale.—See under "Apple and Quince" (p. 11). Treatment for the Italian pear scale above will also suffice for this insect.

Cankerworms.—See page 148.

Red-humped Caterpillar.—See under "Plum and Prune" (p. 104).

Codling Moth, *Carpocapsa pomonella* (Linn.).—See under "Apple and Quince" (p. 13). The control of this insect on pears is not so difficult as on apples, but thorough work is necessary to insure clean fruit, particularly in districts where large acreages of pears are grown.

Fresh pears held in packing-houses or warehouses are often infested with small codling-moth larvae, the "invisible worms" so called because their entrance holes at the calyx are not conspicuous. They may be killed and injury to the fruit prevented by fumigating with methyl bromide at the concentration of 2 pounds per 1,000 cubic feet for a 2-hour period. The temperature must be between 65° and 95° F. Such work should only be done by an experienced fumigator.[31]

Fruit Tree Leaf Roller.—See under "Apple and Quince" (p. 12).

Branch and Twig Borer.—See under "Apricot" (p. 16).

Cherry or Pear Slug.—See under "Cherry" (p. 47).

PEPPER

(See also "Tomato," p. 123)

Green Peach Aphid.—See under "Bulbs" (p. 33). This aphid spreads mosaic of pepper, in which the leaves are mottled and dwarfed as in some of the potato and tomato mosaic diseases.

Small Darkling Ground Beetles, *Blapstinus* spp.—These beetles may girdle the plants, as shown in figure 120. For control see under "Tomato" (p. 130).

Pepper Weevil, *Anthonomus eugenii* Cano.[32]—The small, white grubs feed inside the buds of bell, sweet, or chili peppers and thus cause the buds and most of the pods to drop off. Just before reaching maturity, the pods are glossy and tough and are resistant to weevil, but most of the pods fall and serve as a source of infestation for the field. The adult weevils are about 1/10 inch long, reddish-brown to black with a brassy luster, with a curved beak. Several generations occur a year. In order to give constant protection to the plants, especially to the new buds and pods produced throughout the season, repeated applications of a 50 per cent natural cryolite and 50 per cent talc dust are necessary. The dust should be applied every 7 days, and in severe infestations the first three applications should be made at 5-day intervals. Enough cube or derris powder to impart a 0.5 per cent rotenone content in the final mixture will reduce aphid development, which is stimulated through the use of cryolite.

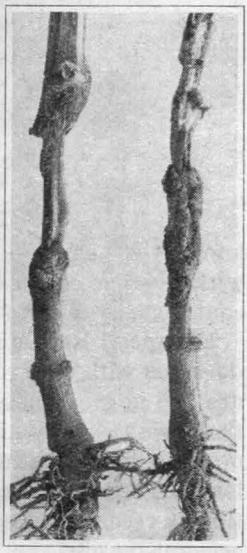


Fig. 120.—Pepper plants showing girdling injuries by the small darkling ground beetles. (Photograph by R. E. Campbell.)

[31] See: Mackie, D. B. The fumigation of fresh fruit with methyl bromide under industrial conditions. California Dept. Agr. Bul. 29:78–86. 1940.

[32] Mr. Roy E. Campbell supplied information for this section.

The rate of application varies from 15 to 30 pounds per acre, according to the size of the plants. Any residue left on the pods can be removed by adequate washing machinery, which provides constant agitation in a hot bath of 2 per cent hydrochloric acid.

PLUM AND PRUNE

Combined Spraying.—For scale, moss, and a general cleanup, spray in winter with heavy oil emulsions or tank mix (p. 167).

Almond Mite.—See under "Almond" (p. 7).

Two-spotted Mite, *Tetranychus bimaculatus* Harvey, **and Pacific Mite** *T. pacificus* McG.—These two mites are very similar in habits and appearances. See "Pacific Mite" under "Grape" (p. 73). They appear on the trees in injurious numbers in midsummer and cause the leaves to turn brown, dry, and fall off. To control: (1) dust with sulfur only in those districts where sulfur is

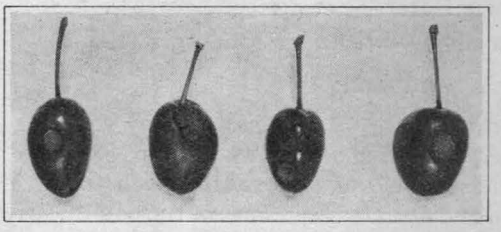


Fig. 121.—Scabbing on Sugar prunes caused by early attacks of the flower or grass thrips.

known to be effective; (2) dust with dinitro dusts (see p. 160); or (3) spray with 1½ per cent summer-type oil emulsion or emulsive oils. Any of these controls may need to be repeated in a single season.

European Red Mite, *Paratetranychus pilosus* (C. and F.).—This mite is dark red with four rows of long white spines on the back. The small, red eggs are laid in great masses on the bark of the twigs in the fall. The eggs hatch in the spring shortly after the trees bloom. The young are bright red. In May or June, heavily infested trees look silvered or bronzed, but do not lose their leaves. Dust with straight sulfur or commercial dinitro dusts (use manufacturer's recommendations), or spray with 1½ per cent medium oil emulsion or emulsive oil.

Flower or Grass Thrips.—See under "Peach and Nectarine" (p. 95). The effect of this pest is shown in figure 121.

Pear Thrips.—See under "Pear" (p. 99). The use of sprays or rotenone dusts (0.75 per cent) is a well-established practice. A minimum of 30 pounds per acre during the jacket stage is recommended. In severe cases (fig. 122) a second application, especially on Imperials, should be made about a week later. Dinitro dusts (about 1 per cent dinitro-*o*-cyclohexylphenol; see p. 160) will also give a fairly good kill of the larvae; or about 1½ per cent dinitro-*o*-cresol. Excessively heavy applications should be avoided. If cankerworms are present, pyrethrum sprays or dusts (see "Bean Thrips" under "Bean," p. 24) should be used.

Minor Cicada, *Platypedia minor* Uhler.—The nymphs live below ground for about four years, feeding on the roots of the trees. In the summer the nymphs crawl a few feet up the trunks of the trees, and the adults emerge, leaving their cast skins on the bark. The adults are about ¾ inch long with bronze-black bodies and clear wings. They puncture small twigs, usually in

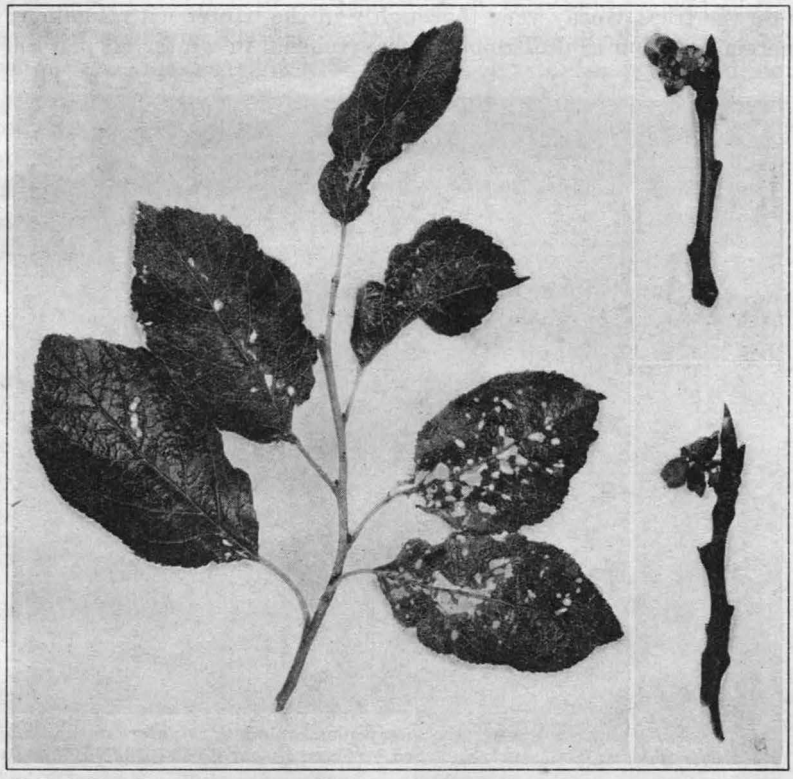


Fig. 122.—Pear-thrips injury to prunes. The holes in the leaves result from the larval injury done as the leaves are unfolding. Typical blossom-bud injury by the adult thrips is shown at the right. (From Cir. 346.)

the centers of the trees, and insert their eggs into them. This causes the twigs to snap when loaded with fruit. Annual covercrops and cultivation usually keep this pest in check.

Plant Bugs and Grass Bugs.—See under "Alfalfa" (p. 3) and "Peach and Nectarine" (p. 96).

Hop Aphid, *Phorodon humuli* (Schr.).—This pale-green aphid passes the winter in the egg stage on plums and prunes. The eggs hatch in the early spring and large colonies of aphids are sometimes found on the plum leaves. These aphids migrate in late spring to hops and seldom warrant control on the plums and prunes. Coal-tar distillate and dinitro sprays, as recommended for mealy plum aphid, control this insect in the egg stage. If spring control is necessary, spray with 1 per cent light summer oil plus ½ pint commercial

nicotine sulfate solution per 100 gallons of water; or dust with a 4 per cent nicotine dust. See also under "Hop" (p. 79).

Mealy Plum Aphid, *Hyalopterus arundinis* (Fab.).—This pale-green aphid (fig. 123), covered with a fine white mealy wax, collects in great numbers on the undersides of the leaves in May and June and is responsible for splitting and smudging the fruit and stunting the tree. The winter is passed in the egg stage on the trees. Spray very thoroughly in the winter with 2 gallons of a commercial solution of dinitro-*o*-cyclohexylphenol in winter oil per 100 gallons of water; or 3 pints of a commercial aqueous solution of sodium dinitro-*o*-cresolate plus wetting agent per 100 gallons of water; or coal-tar distillate emulsion diluted to 2 gallons of actual coal-tar distillate per 100 gallons of water. Less efficient methods consist in spraying in the spring, when 5 per cent of the flowers are in bloom, with 2 gallons of light summer-type oil emulsion plus ½ pint of nicotine sulfate per 100 gallons of water, or dusting with 4 per cent nicotine dust or spraying with pyrethrum and oil vapor spray (formula 10, p. 165) when the aphids appear in colonies on the leaves.

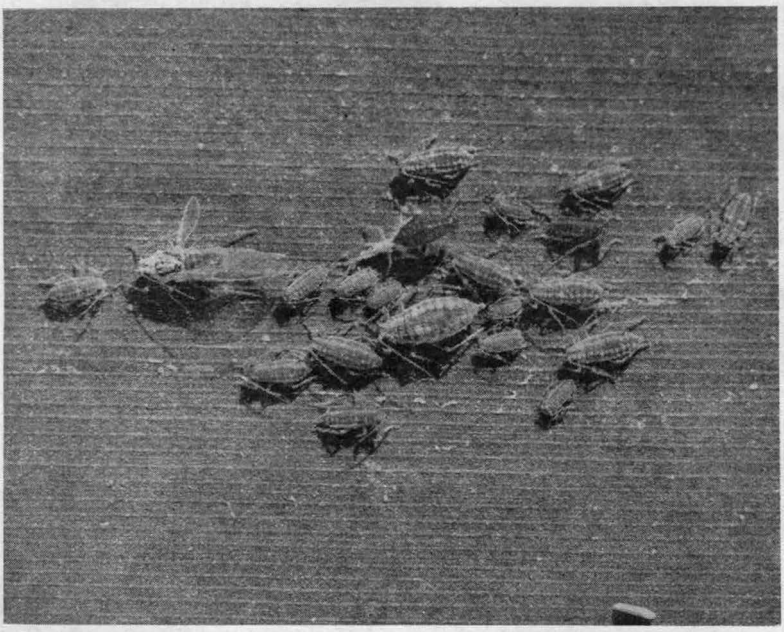


Fig. 123.—A summer colony of the mealy plum aphid, *Hyalopterus arundinis* (Fab.), on cattail. (Greatly enlarged.) (From *Hilgardia* Vol. 10, No. 7.)

Brown Apricot Scale.—See under "Apricot" (p. 15).

Black Scale.—See "Brown Apricot Scale and Black Scale" under "Apricot" (p. 15).

Italian Pear Scale.—See under "Pear" (p. 100).

San Jose Scale.—See under "Apple and Quince" (p. 11).

Red-humped Caterpillar, *Schizura concinna* (A. & S.).—The caterpillars are beautifully lined, reddish-black and yellow, with a conspicuous red hump

on the back. They feed in large colonies and may entirely defoliate individual limbs or entire trees during the spring and again in the fall of the year. They spin no webs, appear also in the fall, and should not be confused with the tent caterpillars, which appear in the spring. Control measures consist in cutting out and burning the entire colonies when small, or in spraying with 4 pounds of basic lead arsenate per 100 gallons of water, or, better, in dusting the infested trees with powdered basic lead arsenate thoroughly mixed with equal parts of hydrated lime. The dusting may be effectively done with either a hand or a power machine. See figure 155 (p. 132). Pyrethrum or rotenone sprays, which may be applied for the control of other pests, will successfully control the red-humped caterpillar. See also under "Walnut" (p. 133).

Tent Caterpillars.—See page 147.

Tussock Moths.—See under "Apple and Quince" (p. 11).

Cankerworms.—See page 148.

Eye-spotted Bud Moth.—See under "Apple and Quince" (p. 13).

Fruit Tree Leaf Roller.—See under "Apple and Quince" (p. 12).

Pacific Peach Tree Borer.—See under "Peach and Nectarine" (p. 97).

Peach Twig Borer.—See under "Peach and Nectarine" (p. 97).

Indian-Meal Moth.—See under "Dried Fruits" (p. 65).

Dried-Fruit Beetle.—See under "Dried Fruits" (p. 66).

Western Flat-headed Borer.—See under "Apple and Quince" (p. 15).

Shot-Hole Borer.—See under "Apricot" (p. 16).

Cherry Fruit Sawfly.—See under "Cherry" (p. 47).

Cherry or Pear Slug.—See under "Cherry" (p. 47).

POTATO

Combined Spraying.—Bordeaux mixture will not only repel the flea beetles but will also aid materially in subduing many fungus diseases.

Root-Knot Nematode, *Heterodera marioni* (Cornu).—This microscopic roundworm produces a pimply or warty surface on the potato and small brown dots just beneath the skin. Plant only clean seed and avoid infested soil. (See also p. 136).

Grasshoppers.—See page 142.

Tomato or Potato Psyllid, *Paratrioza cockerelli* (Sulc.).—The immature forms (fig. 124) are flat, disklike, and yellowish, and have a characteristic marginal fringe. The adults somewhat resemble aphids, are yellow, and jump readily. All mature forms are winged. This insect is widespread in the state and causes "psyllid yellows," which may seriously injure the plants. For control use a dust composed of 1 part of pyrethrum con-

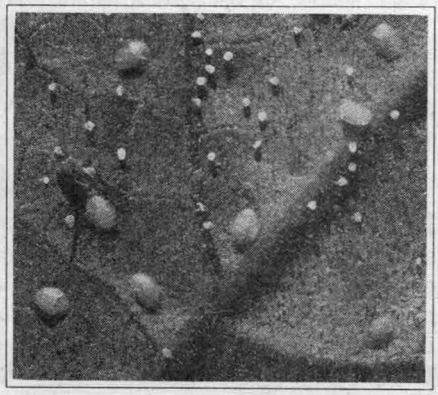


Fig. 124.—The tomato or potato psyllid, *Paratrioza cockerelli* (Sulc.): nymphs and small white pellets of honeydew or excrement. (About four times natural size.)

centrate to 9 parts of talc, or an organic thiocyanate dust containing 2 per cent Lethane. See also under "Tomato" (p. 123).

Green Peach Aphid, *Myzus persicae* (Sulzer).—One of the commonest aphids on potatoes, the green peach aphid may occur on the shoots and undersides of the leaves. It is one of the most effective vectors of virus diseases[33] of potatoes and many other plants. For control apply oil and nicotine spray (formula 13, p. 168). See also under "Bulbs" (p. 33).

Potato Aphid, *Macrosiphum euphorbiae* (Thos.) (*M. gei* Koch, *M. solanifolii* Ashm.).—A large, uniform green or pinkish aphid infests particularly the young shoots and terminal growth. It is a vector of several potato virus diseases. Control is rather difficult and consists in one or more applications

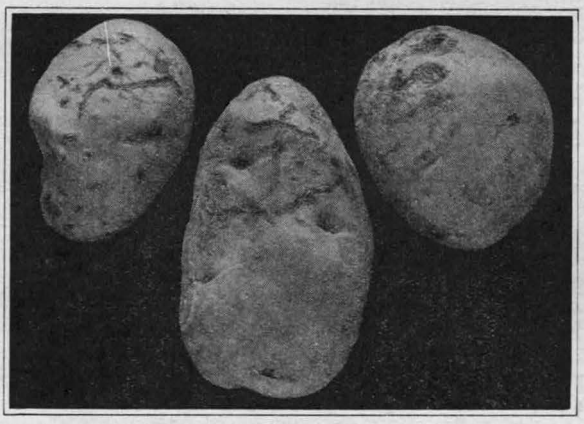


Fig. 125.—Potatoes showing injury caused by the larvae of the western potato flea beetle, *Epitrix subcrinita* Lec. (Courtesy A. J. Hanson.)

of 2 per cent nicotine dusts or nicotine and soap spray (formula 16, p. 171), oil and nicotine spray (formula 13, p. 168), or pyrethrum and oil spray (formula 18, p. 172).

Wireworms.—See page 149.

Potato Flea Beetle, *Epitrix cucumeris* Harris, **and Western Potato Flea Beetle,** *E. subcrinita* Lec.—These insects are minute flealike beetles, the first shining black and the second metallic bronze. The adults perforate the leaves early in the spring and the larvae feed on the tubers (fig. 125) causing pimpling, ridging, and other roughening of the peel and making burrows into the interior. The only practical control measures are directed against the adults. Early-planted potatoes suffer most. Small fields are damaged more than large plantings. A 25 per cent sodium fluosilicate dust applied at intervals of 10 days during the period of infestation gives fair protection to the growing plants. Commercial dusts of cryolite, sodium fluosilicate, and rotenone have also proved satisfactory. Bordeaux mixture (formula 4, p. 158) acts as a repellent to the beetles.

Potato Stalk Borer, *Trichobaris trinotata* (Say).—The larvae are small, pale yellow or white, and not over ½ inch long; they bore throughout the

[33] See: Smith, Ralph E. Diseases of truck crops. California Agr. Ext. Cir. 119:69–71. 1940.

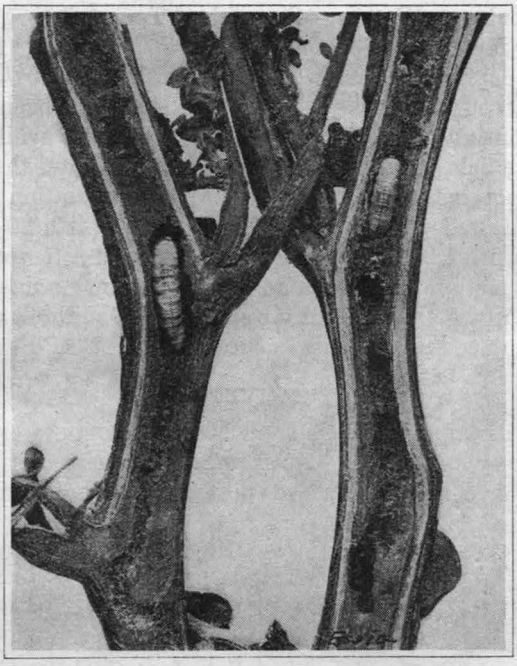


Fig. 126.—Larvae of the potato stalk borer, *Trichobaris trinotata* (Say), in potato stems.

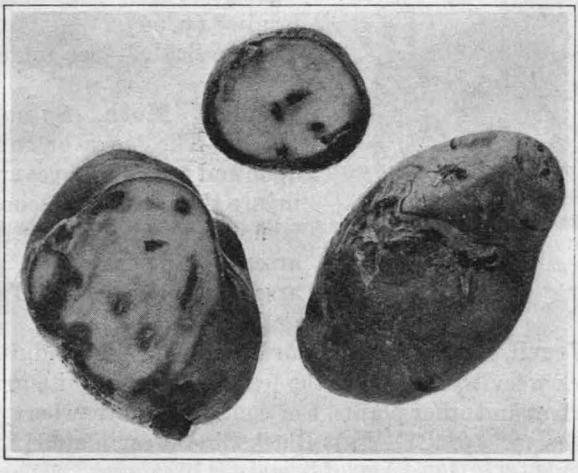


Fig. 127.—Characteristic work of the larvae of the potato tuber moth, *Gnorimoschema operculella* (Zell.), in potatoes.

middle of the stalks (fig. 126) and cause them to wilt and die. The adults hibernate in the old dry stalks, which should be raked up after digging and burned. This affords an almost perfect control if thoroughly done.

Armyworms and Cutworms.—See page 148.

Tomato and Tobacco Worms.—See under "Tomato" (p. 127).

Potato Tuber Moth, *Gnorimoschema operculella* (Zell.) (*Phthorimaea*).—The full-grown caterpillars are white or pinkish and not over ¾ inch long. They make numerous burrows just under the skin and throughout the tubers (fig. 127) and continue to work as long as the tubers are available. Infestation may occur in the field or in storage. Hill up well around the growing plants and remove the potatoes as soon as dug to prevent infestation in the field. Store in a clean, uninfested place. If infested, fumigate with 20 to 30 pounds of carbon disulfide per 1,000 cubic feet of air space at a temperature of 70° F or above or with methyl bromide in a 27-inch vacuum fumigator at the rate of 2½ pounds per 1,000 cubic feet of air space for 90 minutes at a temperature of 70° or above. (See under "Nuts in Storage," p. 87). Plant only clean seed.

PRIVET

Privet Mite, *Tenuipalpus bioculatus* McG.—A minute crimson mite with two large ocular spots (fig. 128) is often very injurious. It causes yellowing of the leaves. For control see "Two-spotted Mite and Pacific Mite," under "Plum and Prune" (p. 102).

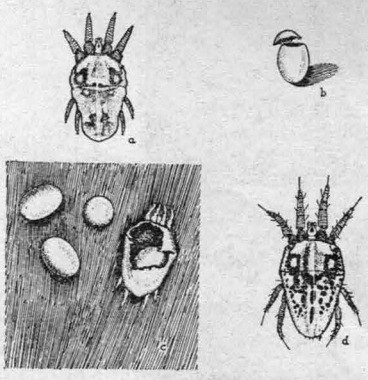


Fig. 128.—The privet mite, *Tenuipalpus bioculatus* McG.: adults and eggs. (Greatly enlarged.) (After McGregor.)

Citrophilus Mealybug.—See "Mealybugs" (p. 142).

Black Scale.—See under "Citrus Fruits" (p. 53).

San Jose Scale.—See under "Apple and Quince" (p. 11).

Red Scale.—See under "Citrus Fruits" (p. 54).

Olive Scale.—See under "Olive" (p. 90).

Privet Moth, *Pyrausta gracilalis* Hulst.—The larva of this insect feeds upon and rolls the leaves and may greatly injure the plants. As soon as the injury is noticed, dust with straight calcium arsenate or spray with standard lead arsenate at the rate of 3 pounds per 50 gallons of water.

Cribrate Weevil, *Brachyrhinus cribricollis* Gyll.—The adults, small, dark-brown or black weevils, feed upon the leaves, and the white grubs feed upon the roots of privet and other plants. For control see "Strawberry Root Weevil" under "Strawberry" (p. 121), and "Black Vine Weevil" under "Bush Fruits" (p. 35).

PUMPKIN

(See "Melons," p. 83)

QUINCE

(See "Apple and Quince," p. 8)

RADISH

(See also "Cabbage," p. 37)

Wireworms.—See page 149.

Vegetable Weevil.—See under "Carrot" (p. 42). This weevil is particularly fond of radish and causes injury to the young plants. Dust with 33 per cent cryolite dust diluted with talc in the spring when the larval work first appears.

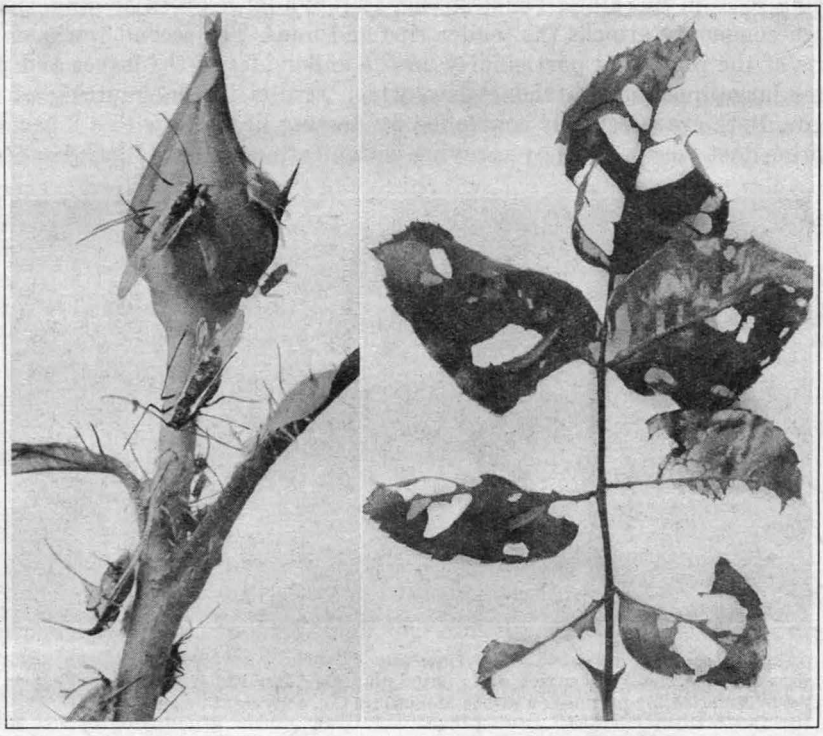


Fig. 129 Fig. 130

Fig. 129.—The rose aphid, *Macrosiphum rosae* (Linn.); this insect usually occurs on the tips of the new growth and buds.

Fig. 130.—The bristly rose slug, *Cladius isomerus* Norton, a green wormlike larva which skeletonizes the leaves of roses. (After Essig, *Insects of Western North America*, by permission of the Macmillan Co., copyright owners.)

RHUBARB

Rhubarb Spittlebug, *Aphrophora permutata* Uhler.—Characteristic froth areas indicate the presence of the larval forms. Control is usually unnecessary.

Bean Aphid.—See under "Bean" (p. 25).

Green Dock Beetle, *Gastroidea cyanea* Melsh.—The bright-green adults are ⅕ inch long and appear in the spring. Control measures are usually not necessary.

RICE

(See "Grain," p. 71)

ROSE

Two-spotted Mite.—See under "Bean" (p. 23).

Flower or Grass Thrips.—See under "Peach and Nectarine" (p. 95).

Rose Aphid, *Macrosiphum rosae* (Linn.), **and Small Green Rose Aphid,** *Myzaphis rosarum* (Walk.).—These two aphids are the commonest ones infesting roses in this state. The first (fig. 129) is a large green or pink species which commonly attacks the tender tips and buds. The second works on all parts of the plant and particularly on the undersides of the leaves and produces large quantities of honeydew, which results in the smutting of the plants. Both are effectually controlled by dusting liberally with a 2 per cent nicotine dust (see p. 171), by spraying with nicotine sulfate (Black Leaf 40),

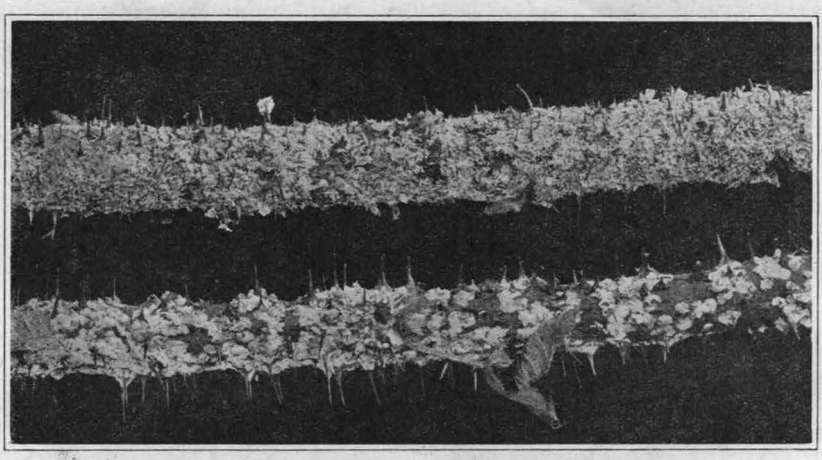


Fig. 131.—The rose scale, *Aulacaspis rosae* (Bouché), a white scale that attacks roses, blackberries, raspberries, and related plants. (After Essig, *Insects of Western North America,* by permission of the Macmillan Co., copyright owners.)

1 part to 800 parts of water, or with nicotine and soap (formula 16, p. 171), or by thoroughly hosing the plants every 2 or 3 days with strong water pressure and a coarse stream from the nozzle.

Rose Scale, *Aulacaspis rosae* (Bouché).—See under "Bush Fruits" (p. 35). Spray infested portions of the plants (fig. 131) during the winter months with emulsive oils.

Rose Snout Beetle, or Rose Curculio, *Rhynchites bicolor* Fab.—This small red and black snout beetle, scarcely ¼ inch long, punctures the buds of roses, and causes numerous holes in the petals when the flowers open. Control by jarring beetles into a pan of oil in the early morning. A 4 per cent nicotine dust has given good control in some places. Lead arsenate, as recommended for the bristly rose slug, applied as soon as the injury is noticed, also gives satisfactory control.

Fuller Rose Weevil.—See under "Citrus Fruits" (p. 55).

Bristly Rose Slug, *Cladius isomerus* Norton.—This slug is a small, pale-green, caterpillarlike larva, which eats irregular holes in the leaves (fig. 130) or completely destroys the foliage of rose bushes. The adults are small, black

sawflies, which somewhat resemble diminutive bees. They lay their eggs on the stalk of the leaflets. Two broods of larvae appear, one in early summer and the second in the fall. Spray as soon as the injury is noted with basic lead arsenate (colored green if preferred so as not to be noticeable on the foliage) at the rate of 2 pounds per 50 gallons of water. One application in May or June is usually sufficient.

Raspberry Horntail.—See under "Bush Fruits" (p. 35).

SAGE AND MINT

Sage Plume Moth, *Platyptilia fuscicornis* Zell.—This insect causes serious damage to numerous sages and mints, destroying buds in the "buttons," and is therefore a serious competitor of the honeybee. Beekeepers in the sage regions of southern California are all too familiar with the work of this caterpillar, which is referred to as the "sage weevil." Two color forms of the caterpillars, a green and a purplish red, occur. Before flower buds appear, the caterpillars feed on the plants and tunnel among the terminal foliage; later they cause the conspicuous borings in the flowers. Injury is by tunneling through bud after bud in the button until at times practically all have been destroyed. Three generations occur a year in central California. An ichneumon fly, *Posocentrus* sp., is a common parasite of the caterpillars. No practical control measures are known.

SHALLOT

(See "Onion, Garlic, Leek, Shallot," p. 92)

SNAPDRAGON

Garden Centipede, *Scutigerella immaculata* (Newport).—A small white centipedelike animal about ¼ inch long inhabits the soil especially in greenhouses, truck gardens, and home flower and vegetable gardens (see also under "Asparagus," p. 19). It may often be present in immense numbers and feeds upon the germinating seeds, young rootlets, and underground stems of the plants. In greenhouses and lathhouses it is very destructive to snapdragons, sweet peas, asters, and other plants. Plants grown in raised benches under proper conditions of clean soil and fertilization are less liable to infestation, but plants grown in ground beds may be severely injured. Control is obtained by applying carbon disulfide emulsion 1 to 300 at the rate of 3 to 5 gallons per square yard.

Green Peach Aphid.—See under "Bulbs" (p. 33) and "Potato" (p. 106).

Snapdragon Plume Moth, *Platyptilia antirrhina* Lange.—The small, greenish larvae are at first leaf miners, but later leave their burrows to seek out the tender terminal leaves, bore inside the developing flowers (fig. 132) or seeds, or bore inside the main stems. Two color forms of the mature caterpillars occur, green and purplish red. Pupae are found suspended nakedly from any part of the plants. Adults have a wing spread of from ⅗ to ⅘ inch and have in general a grayish-brown color. Eggs are laid singly on any part of the plant and are distinctly netted and ovate. Three generations a year occur under outside conditions, but continuous multiplication occurs in greenhouses. Control consists in using a pyrethrum and oil spray made up of 1 per

cent of a light-medium oil emulsion (90 per cent unsulfonatable residue or better) and a 2 per cent commercial pyrethrin extract diluted 1–400 or 1–500 (formula 18, p. 172). A pyrethrum dust may also be used. Several applications after each picking may be necessary. Screening the ventilator openings of greenhouses and the small plants assists in averting heavy infestations.

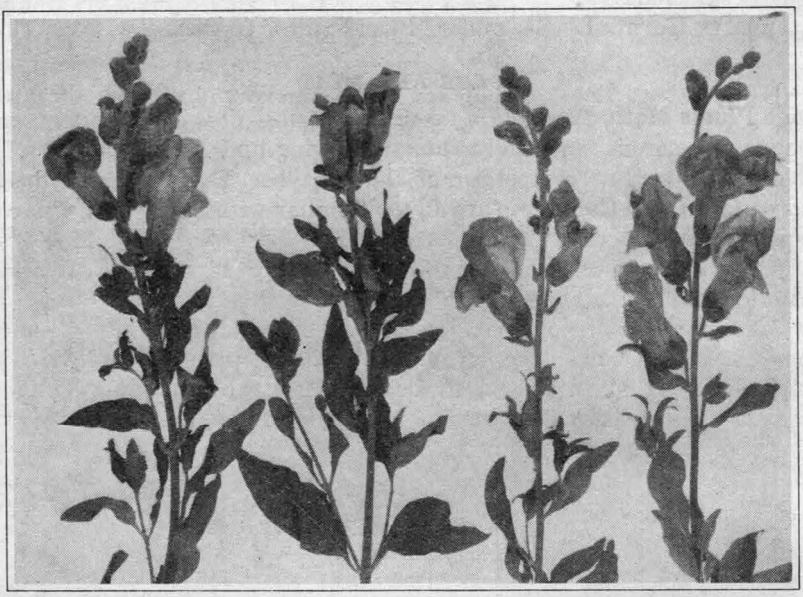


Fig. 132.—Snapdragon flowers showing injury (three left ones) by the caterpillars of the snapdragon plume moth. The right specimen is uninjured.

SORGHUM, SUDAN GRASS, BROOM CORN, AND MILLET

(See "Grain," p. 71, and "Corn," p. 56)

SPINACH

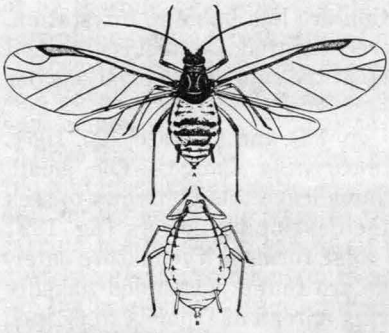


Fig. 133.—The green peach aphid, *Myzus persicae* (Sulz.): Top, adult winged female; bottom, adult wingless female. (Greatly enlarged.)

Grasshoppers.—See page 142.

Beet Leafhopper.—See under "Beet" (p. 27).

Green Peach Aphid, *Myzus persicae* (Sulzer).—This aphid (fig. 133) is often a serious pest of spinach in the spring and early summer. Clean culture and crop rotation give some relief, but control measures are difficult because of the nature of the crop. Unless too serious, the insects can be removed after harvesting by washing. See also under "Bulbs" (p. 33) and "Potato" (p. 106).

Cotton or Melon Aphid.—See under "Cotton" (p. 57) and "Melon" (p. 84).

Armyworms and Cutworms.—Poison bran mash sown broadcast over the fields has proved very successful in completely protecting young plants. Because of the danger of poisoning due to the use of arsenicals and fluosilicates, great care should be exercised to see that no such materials are used on plants, except only on the very young ones. Poison mashes broadcast over the fields should be used only when the plants are young. On older plants sow the poison between the rows. (See p. 144.)

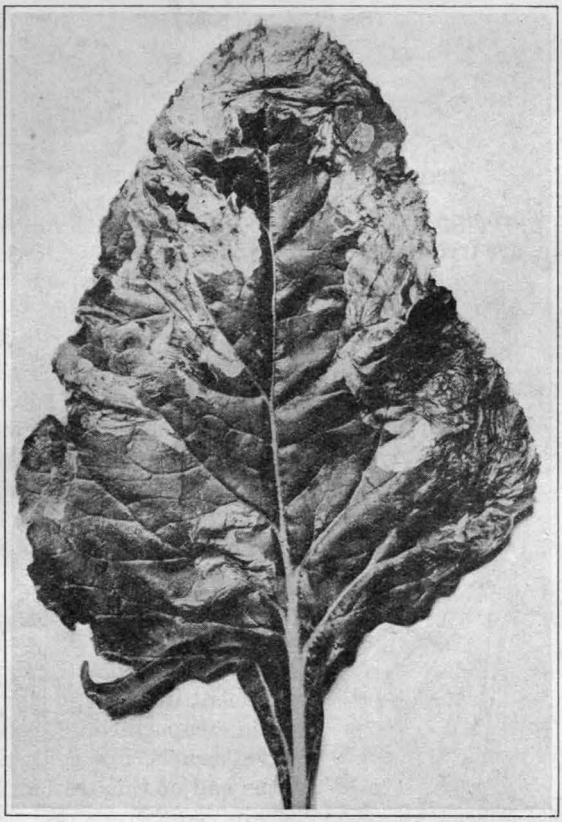


Fig. 134.—A beet leaf showing the injury caused by the mining habits of the larvae of the beet or spinach leaf miner.

Flea Beetles.—See under "Cucumber" (p. 62).

Western Spotted Cucumber Beetle.—See under "Melon" (p. 84).

Spinach or Beet Leaf Miner, *Pegomya hyoscyami* (Panzer).—Small white or yellowish maggots mine the leaves of spinach, chard, or beets, and cause irregular blotches (fig. 134). The maggots pupate in the ground at a depth of 2 to 3 inches. Several generations a year occur. Field sanitation, such as keeping down weeds, burning refuse tops, and harvesting as early as possible, is recommended. The use of insecticides for controlling this pest has not proved satisfactory.

Serpentine Leaf Miner, *Agromyza pusilla* Meigen.—The serpentine mines of this small fly are often rather conspicuous on the leaves of spinach and are most numerous on and destructive to late spinach. To avoid its attacks in areas where this insect occurs in destructive numbers, plant early spinach. Since this insect is even more numerous on peas, it would be well to grow spinach apart from peas if possible. See under "Pea" (p. 95).

SQUASH

(See "Melons," p. 83)

STOCK

(See "Cabbage," p. 37)

STORED CEREALS AND BEANS

Grain Mites, *Tyroglyphus* spp.—Pale-colored mites (fig. 135), smaller than the head of a pin, are frequently found in stored grain and by-products. When abundant, they appear as loose, fluffy masses of gray powder, for the cast skins are mingled with the living mites. Best agents of control are heat and dryness. The mites are killed if subjected to 130° F for several hours. Screening or fanning may reduce the infestation to a satisfactory degree. For further methods of control see discussion at end of this section.

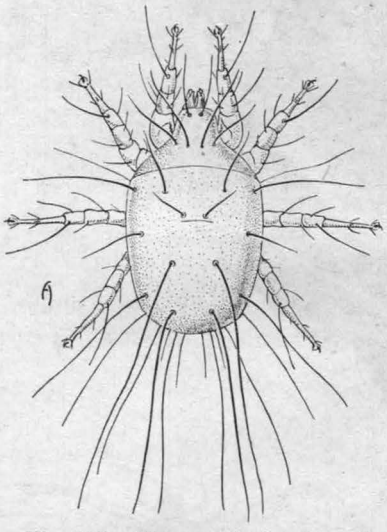


Fig. 135.—The cereal mite, *Tyroglyphus americanus* Banks, a transparent minute pest of cereals and cereal products. (About ninety times natural size.) (From Bul. 676.)

Angoumois Grain Moth, *Sitotroga cerealella* (Olivier).—This small, tawny moth is found in granaries, and is a primary pest of grains. The pale-yellow caterpillars feed and complete their development in stored grain and corn. The adults escape through round holes made in the kernels. For control see discussion at the end of this section. See also under "Grain" (p. 72).

The Mediterranean Flour Moth, *Ephestia kühniella* Zell.—A small, dark-gray moth (fig. 136), having whitish caterpillars, occurs in cereals and cereal products in flour mills, storehouses, stores, residences, and wherever such cereal products are stored. For control see discussion at end of this section.

Indian-Meal Moth.—See "Dried Fruits" (p. 65).

Sawtoothed Grain Beetle, *Oryzaephilus surinamensis* (Linn.).—This insect (see fig. 81, p. 67) is a small, dark-brown, slender, flat beetle, about ⅛ inch long, with a sawlike row of teeth along the sides of the pronotum. Both the adult and the short-legged, pale-colored larva attack broken kernels of grain, and frequently become serious secondary pests of stored grain. For

control see discussion at end of this section. See also under "Dried Fruits" (p. 67).

Cadelle, *Tenebroides mauritanicus* (Linn.).—The adults are about ⅜ inch long, shining black, and much flattened. The larvae are about ½ inch long, pinkish, white, or yellow, with dark-brown or black head, and two hornlike anal appendages. It is a pest of cereal and cereal products, shelled nuts, and similar products. For control see discussion at end of this section.

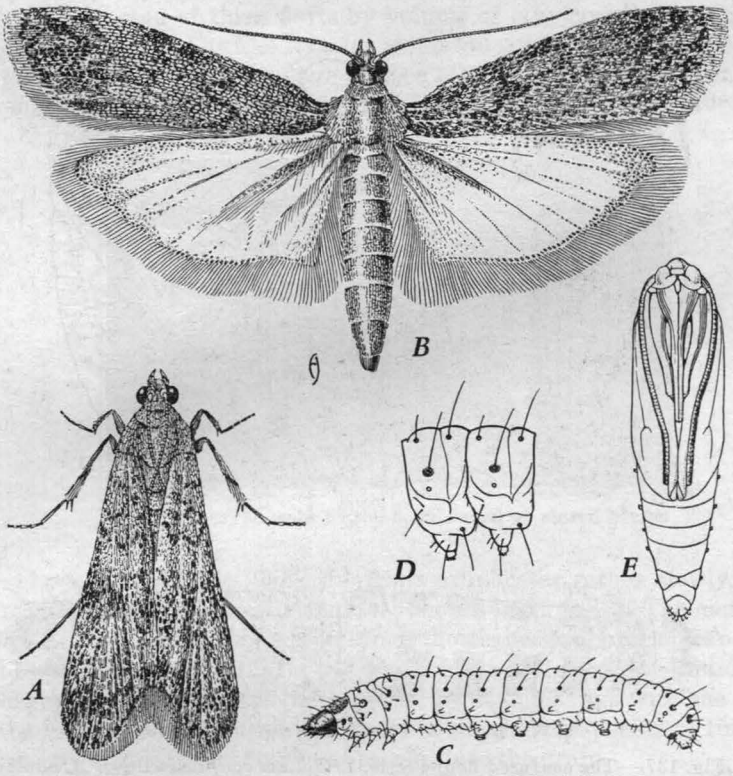


Fig. 136.—The Mediterranean flour moth, *Ephestia kühniella* Zell.: *A*, adult in normal resting position; *B*, adult with wings spread; *C*, larva; *D*, enlarged drawing of two segments of larva in region of prolegs; *E*, pupa. (From Bul. 676.)

Broad-horned Flour Beetle, *Gnathocerus cornutus* (Fab.).—This slender, shining brown beetle is very similar to the confused flour beetle, but is easily distinguished in that its males have large jaws and broad mandibular horns and the larvae do not have the tail piece terminating in two spines. Feeding habits are the same. For control see discussion at end of this section.

Confused Flour Beetle, *Tribolium confusum* Duval, **and Rusty Flour Beetle,** *T. ferrugineum* (Fab.).—These two small, reddish-brown beetles, about 3/16 inch in length, are pests of such products as cereals and cereal products, nuts, and drugs. Both the adults and the narrow, cylindrical, bare, brownish or yellowish, short-legged larvae with a two-spined tail piece are responsible

for the damage done. These insects feed mainly upon broken grain and grain injured by other insects. Several stages of the confused flour beetle are shown in figure 137. For control see discussion at end of this section.

Lesser Grain Borer, *Rhizopertha dominica* (Fab.).—This small, cylindrical, dark-brown beetle, whose length is less than ⅛ inch, is a serious primary pest of stored grain. The eggs are laid on the outside of the grain and through round holes (fig. 138). For control see discussion at end of this section.

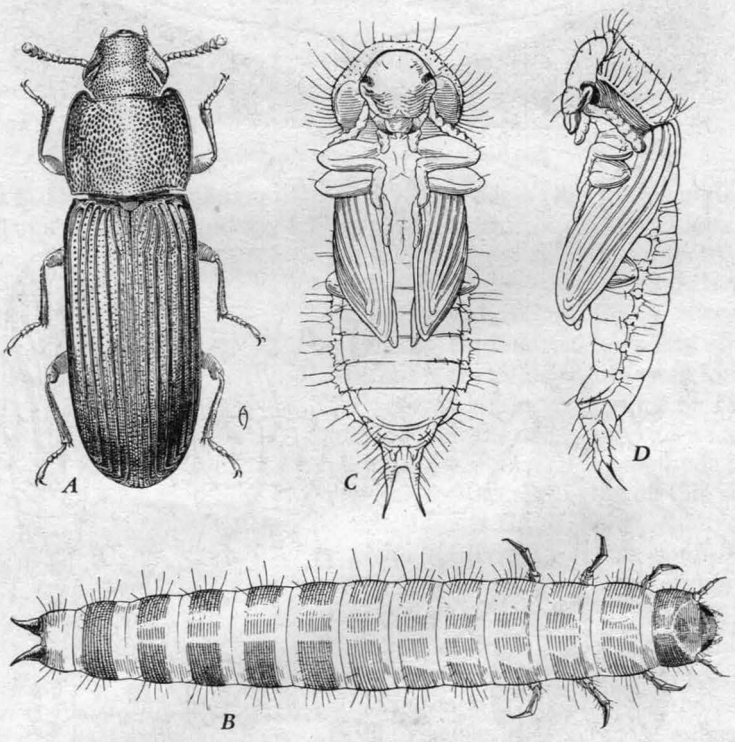


Fig. 137.—The confused flour beetle, *Tribolium confusum* Duv.: *A*, adult; *B*, larva; *C*, pupa, bottom view; *D*, pupa, side view. (From Bul. 676.)

Bean Weevil, *Acanthoscelides obtectus* (Say).—The bean weevil is a short, chunky, squarish beetle with a very short, broad beak, brownish or grayish in color, with short, grayish-brown wing covers having linear black and white markings. Breeding continues in storage, where beans and peas are attacked. The eggs are laid on the outside of the beans and peas. The larvae on hatching eat into the beans, where they complete their development. The adults emerge through round holes (fig. 138). For control see discussion at end of this section.

Granary Weevil, *Sitophilus granarius* (Linn.), **and Rice Weevil,** *S. oryza* (Linn.).—Both species are small, brown or black weevils, not over 1/6 inch in length, which are primary pests of grains in storage. The granary weevil is

shown in figure 139. All stages in their life cycle are completed within the grain. For control see the following paragraphs.

Control.—Control of stored-grain insects can be facilitated by holding grain in tight bins or granaries. Sanitation is also very desirable. Never store grains in bins that have not been thoroughly cleaned. Small amounts of infested grain are very likely to give rise to serious infestations.

Where the grain is infested, the insects can best be controlled by fumigation. Of the many fumigants that might be used, the one that has the least hazard is composed of three parts by volume of ethylene dichloride and one part of carbon tetrachloride. Its odor is not objectionable and it has a rather high toxicity for insects. Although it has a relatively low toxicity for humans, a gas mask should be used if a person is subjected to the vapors for any con-

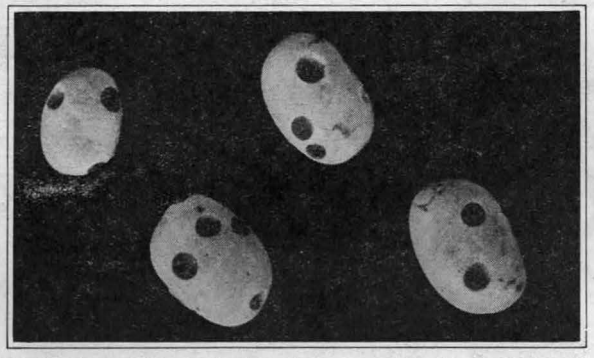


Fig. 138.—The work of the bean weevil on stored beans.

siderable period of time. This fumigant evaporates rather slowly, and for best results a large evaporating surface should be supplied. The material can be placed in large, shallow pans on top of the grain. Evaporation can be facilitated by placing a fan so that it will blow on the surface of the liquid. A large evaporation surface can also be supplied by soaking rags with the material, and the highest concentration of vapors in the shortest period of time can be obtained by spraying the fumigant on and into the grain.

The fumigant should be used under as nearly airtight conditions as possible, and the temperature should not be lower than 70° F. Under nearly ideal conditions, 15 to 30 pounds is necessary per 1,000 cubic feet of chamber space, the amount depending on airtightness. For ordinary farm bins, 4 to 8 gallons per 1,000 bushels may be needed.

Where small lots are to be fumigated, carbon disulfide can be used if the ethylene dichloride and carbon tetrachloride mixture is not available. Carbon disulfide is very inflammable and explosive when mixed with air and should never be used where there is danger that the vapor will come in contact with flames or sparks of any kind. It should be remembered that lighted lanterns, cigars, pipes, cigarettes, sparks from electric switches, or motors, static or frictional electricity, sparks caused by friction or by hammering upon metal may cause an explosion of the vapors of carbon disulfide. Only 1 to 2 ounces is needed to fumigate the material that can be placed in a garbage can. It is

best that the fumigation be done out of doors, and for good results the temperature should be 70° F or higher. The lid of the can should be sealed with Scotch tape and where possible the fumigation period should be for 24 hours.

Other fumigants are methyl bromide, chloropicrin, and hydrocyanic acid gas, but these should be employed only by experienced fumigators. All places being fumigated by these materials should be posted as dangerous.[34]

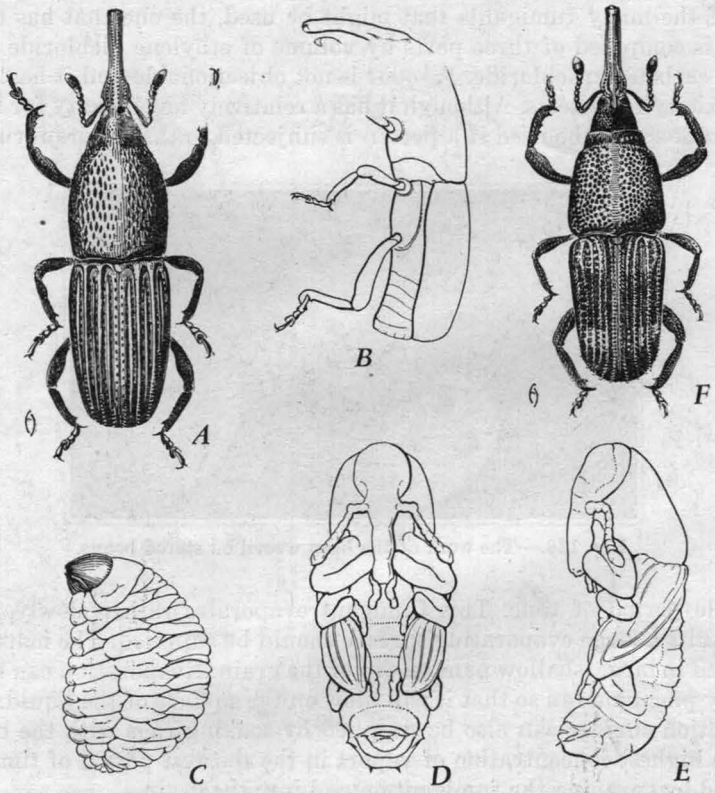


Fig. 139.—*A* to *E*, The granary weevil, *Sitophilus granarius* (Linn.): *A*, adult; *B*, side view of adult; *C*, larva; *D*, bottom view of pupa; *E*, side view of pupa. *F*, the rice weevil, *S. oryza* (Linn.), adult. (From Bul. 676.)

STRAWBERRY

Cyclamen or Strawberry Mite,[35] *Tarsonemus pallidus* Banks.—A very small, amber-colored mite, which is invisible to the unaided eye, attacks several strawberry varieties, particularly Nich Ohmer, while Marshall (Banner) is practically immune. The eggs, greatly enlarged, are shown in figure 140. The damage consists of dwarfing, stunting, crinkling, and slight yellowing or bronzing of the center of the crown of the plant. No method of control is

[34] See: Mackie, D. B., and W. B. Carter. Pest control in rural warehouses and suggested improvements. California Dept. Agr. Bul. 26:275–93. 1937.

[35] See: Smith, Leslie M., and Earl V. Goldsmith. The cyclamen mite, *Tarsonemus pallidus*, and its control on field strawberries. Hilgardia 10(13):53–94. 1936.

known for plants in the field. Hence it is essential to use clean planting stock. All mites on planting stock can be killed by immersing the plants in water at 110° F for 30 minutes, or treating them with air saturated with moisture at 110° F for 1 hour.

Two-spotted Mite, *Tetranychus bimaculatus* Harvey.—This mite passes the winter on strawberries as orange-red forms, usually without black spots. With the advent of warm weather in the spring some of the mites change to amber with two or more black spots. Natural enemies of the mites overwinter on the

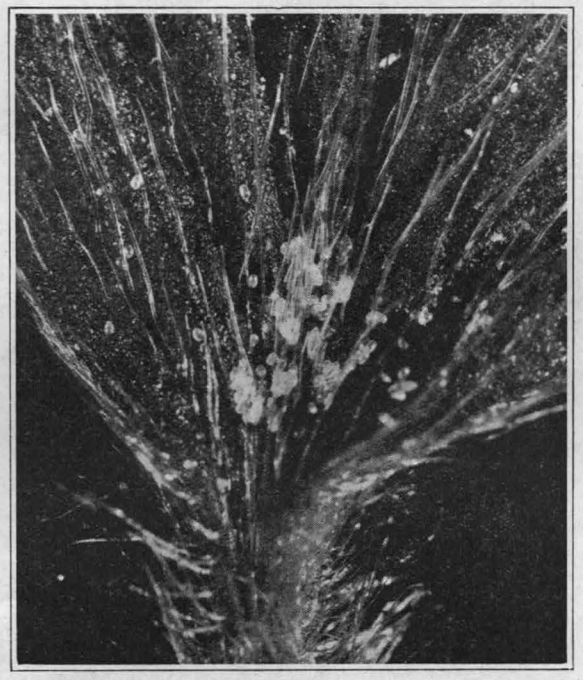


Fig. 140.—Eggs of the strawberry mite, *Tarsonemus pallidus* Banks, at the base of a young unfolding leaf.

plants and are usually numerous enough to control the mites by June. If the natural enemies fail, spray with 1½ per cent summer-type oil emulsion. This may burn the upper sides of fruits which are turning red. Prune and burn the tops of the plants in winter to reduce mite population; if possible spray with 1½ per cent medium summer-type oil emulsion about 10 days after pruning.

Strawberry Aphid, *Capitophorus fragaefolii* Ckll.—A very small, pale-yellow aphid occurs in great numbers on the undersides of the leaves, and often smuts the foliage. It transmits a serious strawberry disease known as "xanthosis," "yellows," or "degeneration," which is very destructive to the plants. To control, defoliate the plants in winter and dust liberally with 4 per cent nicotine dust as soon as the aphids appear, applying it to the underside of the leaves with an upturned discharge pipe.

Strawberry Root Aphid, *Aphis forbesi Weed.*—A small black aphid often feeds on the roots and petioles of the plants. This aphid is fostered and pro-

tected by ants, particularly the Argentine ant. Controlling the ants may solve the problem; see "Ants" (p. 151). Garden patches should be sprinkled with good force from a garden hose.

Strawberry Crown Borer, *Synanthedon bibionipennis* (Bdv.) (*Aegeria rutilans* Hy. Edw.).—The white caterpillar, about ½ inch long, bores in the crown of the strawberry and raspberry (fig. 141). As a rule, only weakened

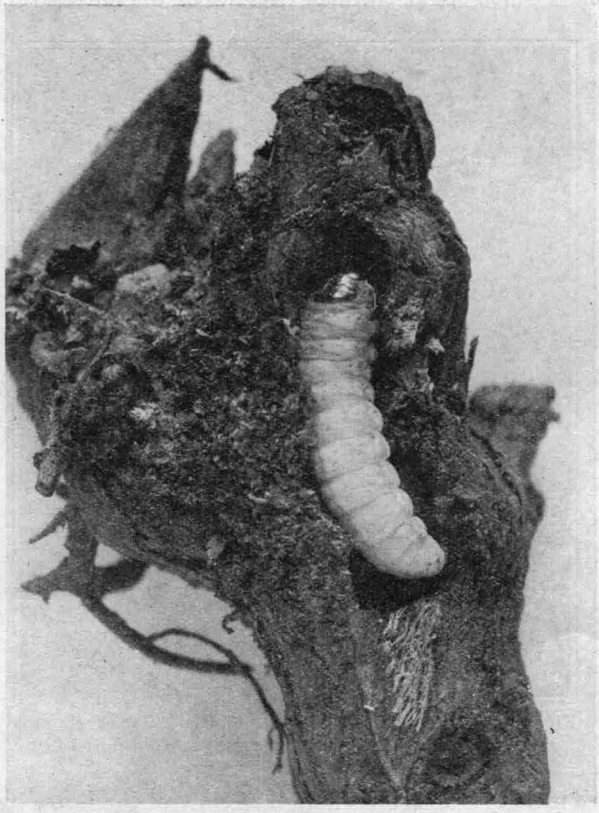


Fig. 141.—Caterpillar of the strawberry crown borer, *Synanthedon bibionipennis* (Bdv.), in a raspberry cane.

plants are attacked, such as those suffering from disease or drought. To avoid this pest, carefully prepare beds to avoid high spots and gravely soil, and irrigate frequently.

Strawberry Flea Beetle, *Haltica ignita* Illiger.—A bright metallic golden green or purplish flea beetle, 1/6 inch long, feeds on the leaves of the plants. Use bordeaux mixture (formula 4, p. 158) as a repellent, or dust with 70 per cent sodium fluosilicate or 40 per cent cryolite if no fruit is to be picked for 6 months.

Strawberry Rootworm, *Paria canella* (Fab.).—The adult, a small, brown beetle with black markings, about 1/8 inch long, eats numerous small irregular

holes in the leaves, and the small white larva feeds on the roots. Control methods are being devised.

Strawberry Root Weevil, *Brachyrhinus ovatus* (Linn.).—The adult is a small, black snout beetle, 3/8 inch long; and the larva is white, crescent-shaped, legless, and about the same length. The adults feed on the foliage and the larvae on the roots of strawberries, and either or both stages may often do great damage. The insect is effectively controlled by the use of poison fruit baits scattered in the fields. Commercial dried-apple bait and certain homemade baits (formula 27, p. 179, or 28, p. 179) may be used. They should be scattered broadcast or along the rows whenever the adults appear, but never on the vines when berries are being harvested.

Black Vine Weevil.—See under "Bush Fruits" (p. 35).

Rough Strawberry Weevil.—See under "Bush Fruits" (p. 35). This insect is shown in figure 142.

Fig. 142. — Rough strawberry weevil, *Brachyrhinus rugosostriatus* (Goeze).

SUNFLOWER

Sunflower Aphid, *Aphis helianthi* Monell.—This dark-green aphid is often abundant on the leaves and terminal shoots of wild and cultivated sunflowers. For control see "Bean Aphid" under "Bean" (p. 25).

Sunflower Phycitid, *Homoeosoma electellum* Hulst.—The larvae of this moth at times literally riddle the seeds in the heads. No satisfactory control is known.

SWEET PEA

(See "Pea," p. 93)

SYCAMORE (PLANE TREE)

Sycamore Eriophyid Mite, *Rhyncaphytoptus platani* Keifer.—A microscopic mite causes a browning of the undersides of the leaves. It sometimes does serious damage to the trees. For control see "Pear Leaf Blister Mite" under "Pear" (p. 99).

Ilicis or Southern Red Mite, *Paratetranychus ilicis* McG.—This minute red species infests a wide variety of ornamental trees and shrubs, especially camphor, cypress, eucalyptus, loquat, evergreen oaks, sycamore (plane tree), and English walnut. Control may be obtained by repeated drenchings with a coarse spray from the garden hose with as much force as possible, or by the application of a spray of light or medium emulsive oils at the rate of 1⅔ gallons per 100 gallons of water.

Pacific Mite.—See under "Grape" (p. 73).

Western Sycamore Lacebug, *Corythucha confraterna* Gibson.—A brownish lacelike bug infests the foliage. Spray during summer with 40 per cent nicotine sulfate (for example, Black Leaf 40), 1 part to 800 parts of water, to which a spreader has been added.

Sycamore Scale, *Stomacoccus platani* Ferris.—This minute, yellow, often cottony, scale insect spends much of the fall and all of the winter under the

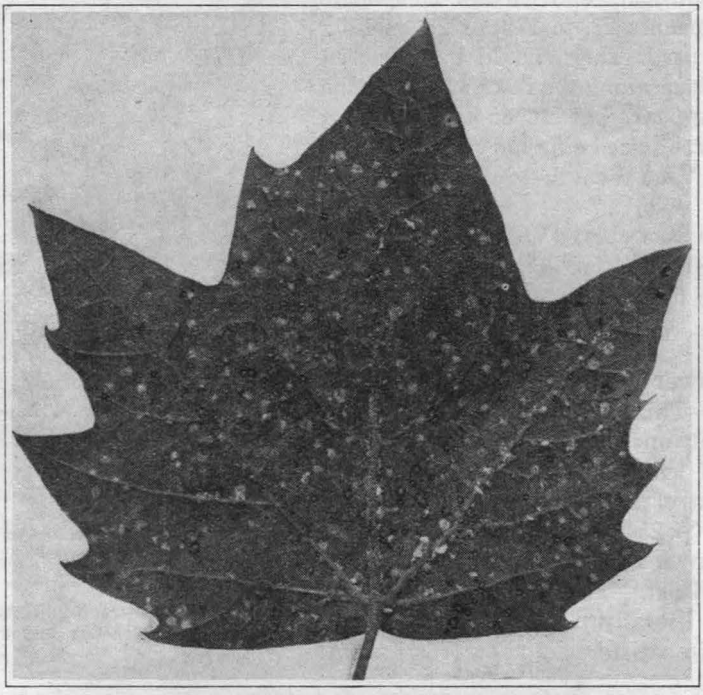


Fig. 143.—Sycamore leaf infested with sycamore scale, *Stomacoccus platani* Ferris. The spots are brown and the leaves are also often severely curled by the attacks of this pest in the early spring.

bark of the tree, and the spring and early summer on the leaves (fig. 143). Eggs are laid under the bark and in crevices. There are several generations a year. It often does severe damage to the foliage in the spring. Control consists in the application, in January, of dormant emulsive oil sprays at the rate of 3 gallons per 100 gallons of water.

Sycamore Borer, *Synanthedon mellinipennis* Bdv.—The adult is a beautiful, yellow and black, wasplike, clearwing moth. The white larvae bore into the trunks and larger limbs of the trees. Control is difficult, but fair results may be had by applying with a paintbrush a solution of 1 pound of paradichlorobenzene in 2 quarts of crude cottonseed oil.

American Plum Borer, *Euzophera semifuneralis* (Walk.).—The adult is a small reddish-brown and black moth. The dusky-greenish or pinkish cater-

pillars bore into and around cracks, wounds, and sunburned areas of the trees. Control is the same as for the sycamore borer.

Western Sycamore Moth, *Gelechia desiliens* Meyrick.—The adult is gray. The small, whitish caterpillar infests the western native sycamore only. For control, spray with standard lead arsenate, 2 pounds to 50 gallons of water.

TOMATO

(See also "Pepper," p. 123, and "Potato," p. 105)

Root-Knot Nematode, *Heterodera marioni* (Cornu).—This pest causes stunted plants and knotted and otherwise swollen roots. See page 136.

Tomato Mite, *Phyllocoptes destructor* Keifer.—The tomato mite has recently proved to be a serious pest. It is a free-living, microscopic mite, which lives on the surface of the stems and leaves. Under high magnification it is whitish yellow and slightly humped. It has legs only on the forward portion of the body. It sucks out the cell contents of the surface of leaves and stems, and produces a brown or russeted appearance. Injury first begins to appear in June but does not become serious enough to be noted until late July and August. Beginning at stems near the ground, the infestation works up the plant, gradually causing the lower leaves to dry up. During hot weather a rapid defoliation of the plants sets in, resulting in sunburned fruit. Only in very serious cases and after the leaves are killed does the mite affect the fruit itself. Up to the present time, it has been most serious in the warmer interior valleys.

Dusting sulfur gives the best control. Some canning concerns, however, have a restriction on the use of sulfur on canning tomatoes. Others will allow growers to use a 25 per cent sulfur dust. When this is allowed, a mixed sulfur and calcium arsenate dust can be used. Such a dust, if applied at 25 to 30 pounds per acre, should materially reduce mite damage and also control hornworms, beet armyworm, the corn earworm, and other armyworms. The area of severest mite damage also covers the region where early dusting for hornworms may be necessary. If the mixed dust is used for the control of hornworms in July and August, it is probable that a serious mite infestation will not develop. Extensive experiments with sulfur and calcium arsenate dust are being conducted, and if they prove as successful as expected, the cost of pest control in heavily infested regions will be materially reduced. On market tomatoes there is no restriction on the use of sulfur.

Grasshoppers.—See page 142.

Tomato Suck-fly, *Cyrtopeltis varians* (Distant).—This slender plant bug, ¼ inch long, somewhat resembles a mosquito, with long legs, an anterior collar, and a green body with black spots. It occurs only in southern California and elsewhere in subtropical regions where tomatoes are grown. Eggs are embedded in the stems. Larval feeding is done in rings around stems; it causes a thickened, corky area and line of weakness. This results in so-called "blossom drop" or dropping of the young tomatoes. Control by means of pyrethrum extract or pyrethrum and oil (formula 18, p. 172) has proved effective, the oil spray being applied in a very fine fog to avoid foliage injury.

Tomato or Potato Psyllid, *Paratrioza cockerelli* (Sulc.).—Psyllid yellows of potatoes and tomatoes is caused by the feeding of this insect and not by a

virus. This disease somewhat resembles curly top and is evidenced by a puckering of the leaflets and curling and twisting of the leafstalk. For description and control of the insect see under "Potato" (p. 105).

Beet Leafhopper, *Eutettix tenellus* (Baker).—The beet leafhopper is the vector of the virus causing curly top, or western yellow blight, of tomatoes (fig. 144). Tomatoes should be grown outside the hazard zone of this insect. See under "Beet" (p. 27).

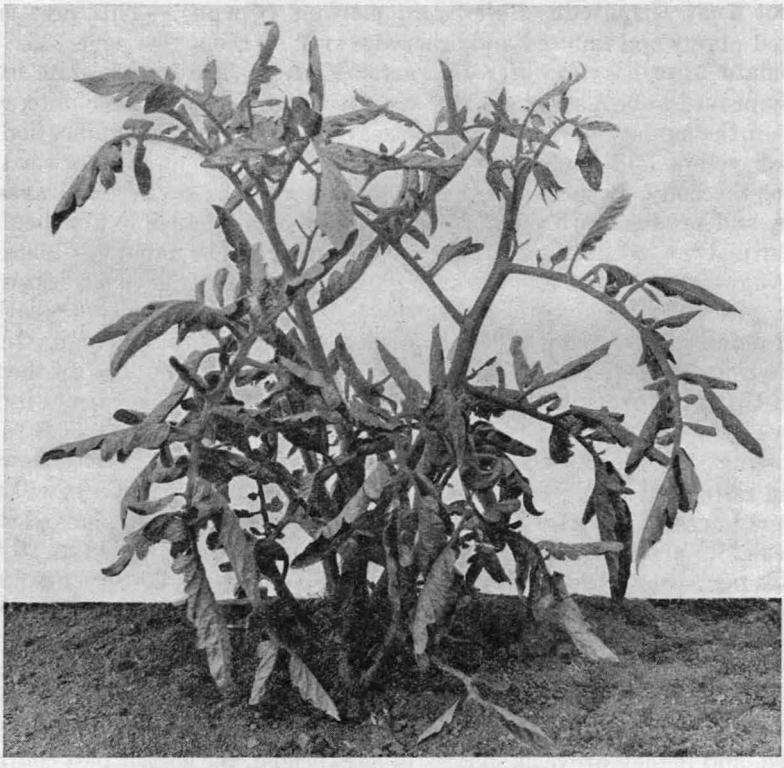


Fig. 144.—Tomato curly top. (From Ext. Cir. 66.)

Green Peach Aphid, *Myzus persicae* (Sulzer).—This and possibly also other species of aphids transmit viruses which cause mosaic diseases of tomatoes. Plant beds should be protected from aphids. There is no practical field control of the aphid, since it is so widely scattered on many kinds of host plants. See under "Bulbs" (p. 33).

Potato Aphid.—See under "Potato" (p. 106).

Beet Armyworm, *Laphygma exigua* (Hbn.).—Two types of armyworms attack tomatoes: (1) those that feed at night and hide in the soil or debris covering it during the day (see p. 144) and (2) those that spend their entire larval life on the plant. This second type includes the beet armyworm, discussed in this paragraph, and the yellow-striped armyworm and corn earworm, discussed in following paragraphs. The beet armyworm is primarily a

foliage feeder, although it frequently injures the fruit; but because it is characteristically an external feeder, fruit injury is usually superficial. Fruit damage is ordinarily most serious where tomatoes are grown for the fresh market. When necessary the pest can be controlled by thoroughly dusting the plants with undiluted calcium arsenate at the rate of from 10 to 25 pounds per acre, according to the size of the vines.

Yellow-striped Armyworm, *Prodenia praefica* Grote.—This armyworm not only feeds on the foliage but may also seriously attack the fruit (fig. 145). Unlike the corn earworm, it does not actually enter the fruit but eats large irregular holes in the surface. It is easily controlled by thoroughly dusting the vines with undiluted commercial calcium arsenate at the rate of from 10 to 25 pounds per acre, according to the size of the vines.

Fig. 145.—The yellow-striped armyworm, *Prodenia praefica* Grote, and injury to tomato. (From Bul. 625.)

Corn Earworm, or Tomato Fruitworm, *Heliothis armigera* (Hbn.).—The adults have a wingspread of about 1½ inches and are fawn-colored, with darker spots on the forewings and with a brown margin and a transverse brown band on each hindwing (fig. 146, *D* and *E*). The eggs, laid at random over the periphery of the vine, are round, somewhat flattened, white or pale yellow, and longitudinally ribbed with very fine lines. During warm weather they hatch in 3 or 4 days.

In summer the larvae mature in 2 or 3 weeks and when full grown are about 1½ inches in length (fig. 146, *A*). They vary in color, ranging from pale green to almost black, and may be marked with stripes of pink, yellow, brown, or other colors. On completing their development, they enter the soil and construct pupal cases a few inches below the surface. The pupae (fig. 146, *B* and *C*) vary from dark amber to chestnut brown and are about ¾ inch long. The pupal period lasts 2 or 3 weeks during the summer, but many larvae that pupate by the middle of September and later, hibernate. In California there are no less than three generations a year.

The corn earworm is one of the most serious pests attacking the tomato

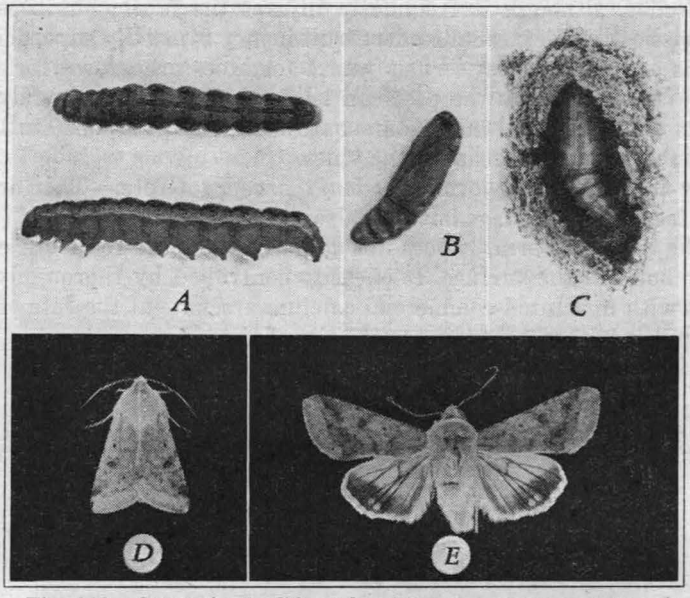


Fig. 146.—Stages in the life cycle of the corn earworm or tomato fruitworm, *Heliothis armigera* (Hbn.): *A*, mature larvae; *B*, pupa removed from earthen cell; *C*, pupa within earthen cell; *D*, adult in a position of rest; *E*, adult with wings spread. (All natural size.)

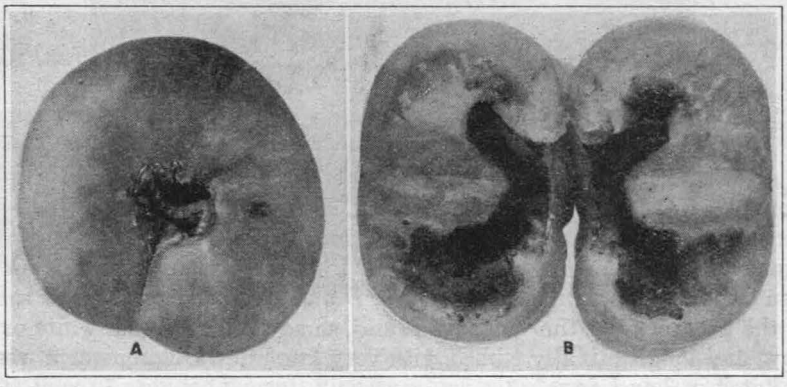


Fig. 147.—Corn-earworm or tomato-fruitworm damage to tomatoes: *A*, advanced injury of the calyx, or stem, end with caterpillar in burrow; *B*, tomato cut in half to show the internal destruction caused by the caterpillar. (From Ext. Cir. 99.)

fruit, although sweet corn is the preferred host. In central California the pest probably builds up on other hosts before migrating extensively into tomato fields. After hatching, the larvae begin feeding on the foliage but soon work their way to the fruit, where they usually burrow in at the stem end. In cases of heavy infestations, 25 per cent or more of the fruit may be destroyed (fig. 147).

If the vines are completely covered with not more than 15 to 25 pounds of calcium arsenate per acre, preferably when dew is on the plants, a high degree of control can be expected. It is not necessary to concentrate materials on the fruits—this, in fact, is an undesirable practice. A 50 to 70 per cent cryolite dust, diluted with talc, has also been found to be effective. On large vines the

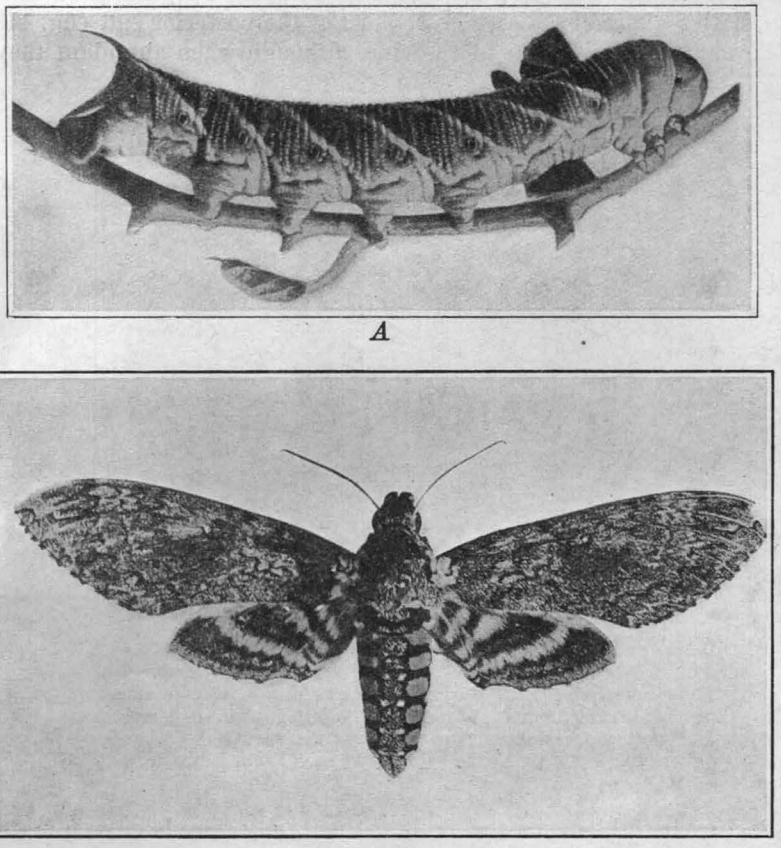


Fig. 148.—The tomato worm, *Protoparce sexta* (Johan.): *A*, larva (after Folsom); *B*, adult.

dust should be applied at a rate of 30 pounds per acre, although smaller amounts may suffice where dusts containing the higher percentages of active ingredients are used. The average cannery washer will remove moderate amounts of insecticidal dust from tomatoes; but where fruit is intended for the fresh market and is dusted during the ripening period, it must be washed or carefully wiped.

Tomato Worm, *Protoparce sexta* (Johan.), and Tobacco Worm, *P. quinquemaculata* (Haw.).—These two large caterpillars, sometimes called "hornworms," are very destructive over part of the tomato-growing section of California. The adults, which fly at dusk, are known as sphinx moths, or

hummingbird moths, and are strong, swift fliers. They are gray, with yellow spots on the sides of the body, and have a wing expanse of 4 to 5 inches (fig. 148, *B*). There are no less than two generations a year, and activity begins early in June and continues until frost. The spherical, smooth, pale-green eggs are laid at random over the plants. After hatching, the larvae grow rapidly, sometimes attaining the length of 4 inches. They are predominantly green, with a characteristic spine or horn at the posterior end (fig. 148, *A*). The larvae are chiefly pests of the vine, although when abundant they may

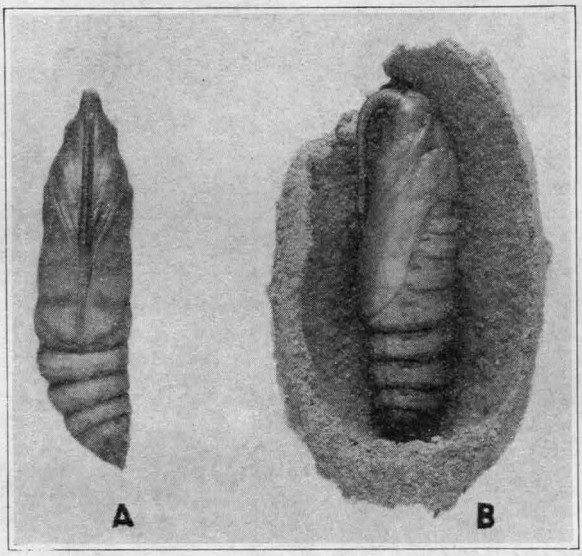


Fig. 149.—*A*, pupa of the tobacco worm, *Protoparce quinquemaculata* (Haw.); *B*, pupa of the tomato worm, *P. sexta* (Johan.), in its cell. The distinguishing character that separates the two species is the sheathed proboscis, which is longer in the tobacco worm. (From Ext. Cir. 99.)

also destroy both blossoms and fruit. At maturity they burrow into the soil, construct an earthen cell, and transform into chestnut-brown pupae (fig. 149) about 2 inches long, which are characterized by the pitcher-handlelike rostrum. The winter is passed in the pupal stage.

When hornworms first appear and vines are small, hand-picking is practical. Later, several applications of straight commercial calcium arsenate dusted evenly and thoroughly over the plants at the rate of 15 to 25 pounds per acre may be necessary to control the pest effectively. If the vines are dusted while the fruit is ripening, the tomatoes should be washed or carefully wiped.

Tomato Pinworm, *Keiferia lycopersicella* (Busck).—The pinworm is one of the most destructive tomato pests in California. Although it causes most serious losses in the southern districts, it is rather widely spread throughout the state, and some damage has occurred in the northern producing sections.

The adults are small, gray moths, ¼ inch in length. The young larvae

are pale with dark head; the older larvae, green with purplish markings. The mature larvae are about ¼ inch long and at a glance appear grayish or greenish purple. Though principally a pest of the fruit (fig. 150), the pinworm also attacks the vine. The larvae generally enter the fruit at the stem end, where they are often unnoticed until picking time. Even then a careful inspection is necessary to detect the injury, particularly if the larvae are small. Feeding is confined to the core and the fleshy portions of the fruit. The injury consists in the construction of burrows, webbing, and frass.

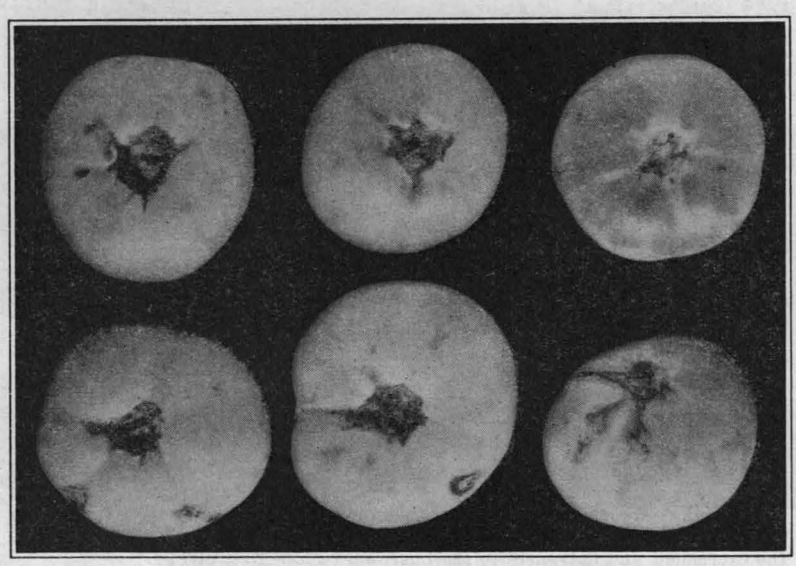


Fig. 150.—Tomatoes seriously infested with the tomato pinworm, showing the several types of injury. (From Bul. 625.)

Because the tomato pinworm breeds in large numbers in abandoned fields, all plants should be destroyed immediately after harvest, either by plowing or by burning the refuse. Piles of infested plants should never be allowed to remain in the field or elsewhere. A 60 to 70 per cent cryolite dust thoroughly and evenly applied to the tomato vines is the most effective insecticide to use against this pest. If the vines are dusted while the fruit is ripening, it should be washed or carefully wiped.

Potato Tuber Moth, *Gnorimoschema operculella* (Zell.) (*Phthorimaea*).—This insect is widespread in many districts of California. There are several generations a year. The adults, which fly by night, are gray, with small silvery bodies, and have minute dark specks on the forewings. The female lays 150 to 200 eggs, small, oval, pearly white, and deposited indiscriminately over the plant. When fully grown the larvae are slightly over ⅜ inch in length and are white, yellow, pinkish, or greenish, with the head and prothoracic shield dark brown. The tuber-moth larvae can be distinguished from pinworm larvae by their lighter color and larger size. They are pests of the fruit (fig. 151) and cause damage similar to that done by the pinworm.

Although some injury may occur in many fields, serious damage is usually

observed only where tomatoes follow potatoes or are being grown in areas largely devoted to potato culture. To avoid severe attack, therefore, it is probably best not to follow potatoes with tomatoes. Serious infestations are almost certain to occur if volunteer potato plants are not destroyed.

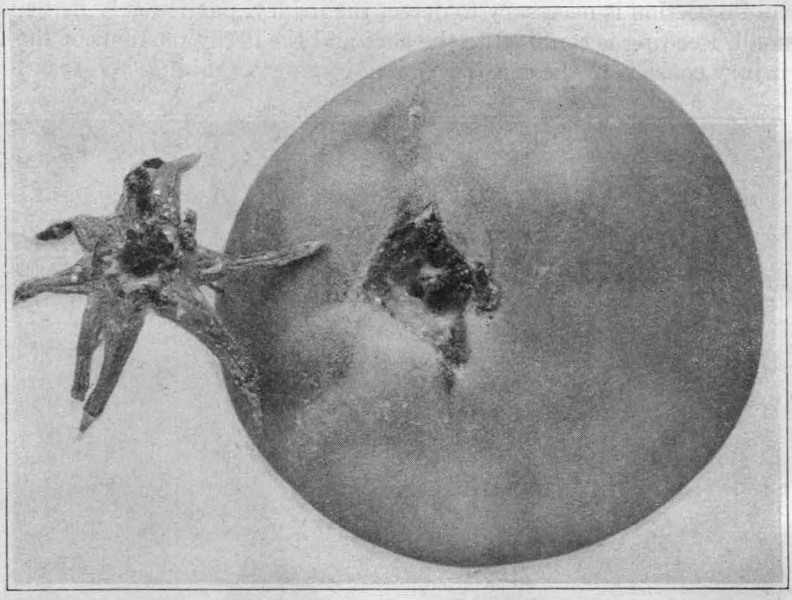


Fig. 151.—Tomato infested at the calyx end by the larva of the potato tuber moth, *Gnorimoschema operculella* (Zell.). The calyx has been removed to reveal the excrement and entrances to the burrows. (From Ext. Cir. 99.)

Small Darkling Ground Beetles, *Blapstinus* spp., **and** *Metoponium abnorme* (Lec.).—Small, dull-black or bluish-black beetles (fig. 152), scarcely more than ¼ inch long, live in the soil and are responsible for much damage to young transplants. (See the illustration of girdling injury to pepper plants, fig. 120, p. 101). Clean culture is advisable because the most serious damage is likely to occur where the land has recently been plowed. Before setting in the field, wrap the stems of the young plants from roots to tops with pieces of newspaper, 4½ by 5½ inches, so that there will be several thicknesses of paper for protection, or scatter poison bran mash (formula 28, p. 179) over the ground at planting time. The pest can also be controlled by thoroughly dusting the plants and the soil about their base, just after transplanting, with calcium arsenate or a 50 per cent cryolite dust. Heavily dusting the plants with hydrated lime will also give good control. A can with small holes punched in the bottom attached to a pole may be used for dusting. A knapsack duster would be preferable.

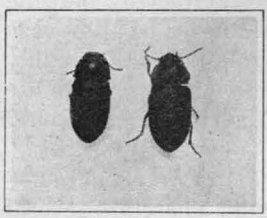


Fig. 152. — Adults of the small darkling ground beetle, *Metoponium abnorme* (Lec.), which often occur in large numbers and severely injure newly transplanted tomatoes.

Flea Beetles.—These small jumping beetles may nearly defoliate newly transplanted tomato plants. They can be controlled by thoroughly dusting the plants with either calcium arsenate or a dust of 50 per cent cryolite and 50 per cent talc. See under "Potato" (p. 106).

Vegetable Weevil.—See under "Carrot" (p. 42).

WALNUT[36]

(See also "Nuts in Storage," p. 87)

Walnut Blister Mite, *Eriophyes erineus* (Nalepa) (*E. tristriatus* [Nalepa] var. *erineus* [Nalepa]).—A microscopic mite produces yellow or brown felt-like galls on the undersides of the leaves (fig. 153). It is not a serious pest,

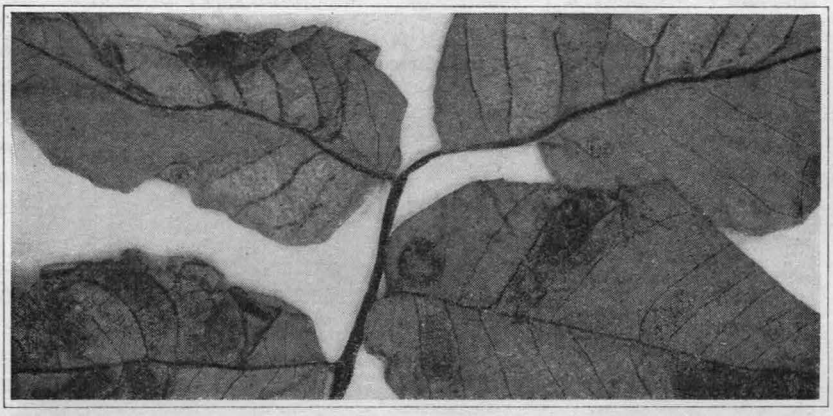


Fig. 153.—Leaves of the English walnut showing the fuzzy patches on the undersides caused by the walnut blister mite.

but may be cleaned up by spraying trees with lime-sulfur, 1–10, in the spring when the buds are swelling. Control measures are not recommended except in extreme cases.

Red Spiders and Mites.—Two-spotted mite, *Tetranychus bimaculatus* Harvey, is pale-colored with two dark areas. Infested leaves turn gray and later brown, and many drop prematurely in summer or early fall. Other associated species, but of much less importance, are the ilicis or southern red mite (*Paratetranychus ilicis* McG.) and the European red mite (*Paratetranychus pilosus* [C. & F.]). In central and northern California the Pacific mite (*Tetranychus pacificus* McG.) appears to be most injurious. To control, dust with dinitro-*o*-cyclohexylphenol dust (DN dust), 3 pounds per tree, applied thoroughly when the first signs of injury are noted.

Walnut Aphid, *Chromaphis juglandicola* (Kalt.).—This pale-yellow, winged or wingless insect (fig. 154) is of very general occurrence on the underside of the leaves, especially in the coastal districts. Injury is due to extraction of sap and the growth of the sooty-mold fungus in excretions of the insect. For control, dust with 40 per cent nicotine sulfate (for example,

[36] For further details see section on walnut insects by A. M. Boyce in: Batchelor, L. D. Walnut culture in California. California Agr. Exp. Sta. Bul. 379:69–78. Revised 1936 by L. D. Batchelor and O. Lee Braucher.

Black Leaf 40) 3 pounds, to 97 pounds hydrated lime (p. 171); or add nicotine sulfate ⅓ to ½ pint per 100 gallons to the basic lead arsenate spray used for codling-moth treatment if timing is correct for both pests. A power machine dusting walnuts for control of aphids is shown in figure 155.

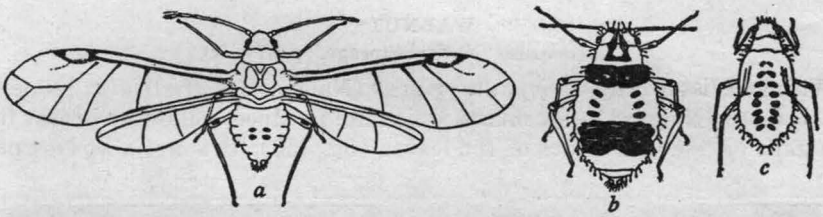


Fig. 154.—The walnut aphid, *Chromaphis juglandicola* (Kalt.): *a*, common winged form; *b*, egg-laying female; *c*, nymph or immature winged form. (Greatly enlarged.)

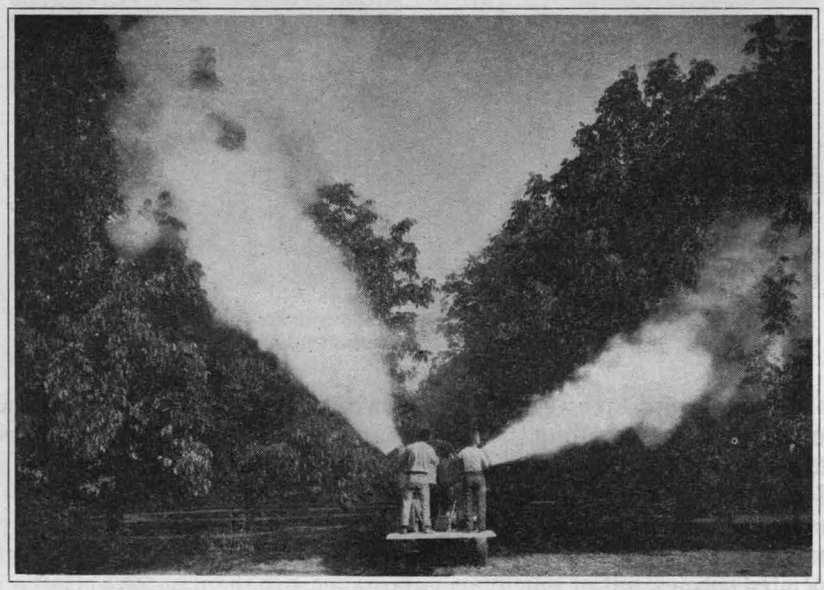


Fig. 155.—Dusting walnuts with a power machine for the control of the walnut aphid.

Scale Insects.—Several species occur on walnut, most of which may be considered as minor pests. The common red scale, *Aonidiella aurantii* (Mask.), is important where control on near-by citrus is a consideration. Control in such cases is by fumigation with cyanide. The calico scale, *Lecanium cerasorum* Ckll., is hemispherical, with yellowish-white areas on a brown background. For control use dormant oil emulsion 3 per cent, or emulsive or tank mix oil 2 per cent. No oils should be used on walnuts in foliage in southern California. The frosted scale, *Lecanium pruinosum* Coq., is a large hemispherical scale with a frosted covering (fig. 156). Control is rarely necessary. The female of the Italian pear scale, *Epidiaspis leperii* (Sign.) (*E. piricola* Del G.),

has a dark-red or purplish body beneath a circular, dark-gray covering. The male is elongate and white. For control use oil and lime-sulfur sprays. (See under "Pear," p. 100.) The walnut scale, *Quadraspidiotus juglans-regiae* (Comst.), is a flat, circular, grayish to reddish-brown scale, occurring on twigs. Control by commercial lime-sulfur spray, 5 or 6 gallons to 95 to 100 gallons of water.

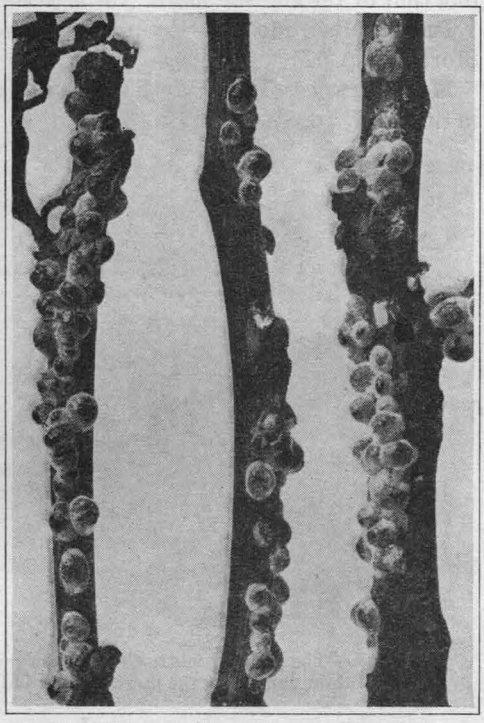


Fig. 156.—The frosted scale, *Lecanium pruinosum* Coq., on walnut.

Red-Humped Caterpillar, *Schizura concinna* (A. & S.).—These striking black-and-yellow-striped caterpillars (fig. 157), with red head and red hump, are sometimes abundant on walnut trees in late summer, when the leaves may be entirely removed. At this season, control measures are not usually advisable, except possibly on young trees. See under "Plum and Prune" (p. 104).

Codling Moth, *Carpocapsa pomonella* (Linn.).—See also under "Apple and Quince" (p. 13). The larva (fig. 158) bores into the husk and shell or through the suture at the base, and feeds on the meat of the nut. Piles of small brown particles (frass), commonly where two nuts are in contact, is evidence of infestation. Control by spraying with basic lead arsenate (formula 2, p. 156) at the time indicated by bait traps (formula 35, p. 182), usually in May or June.

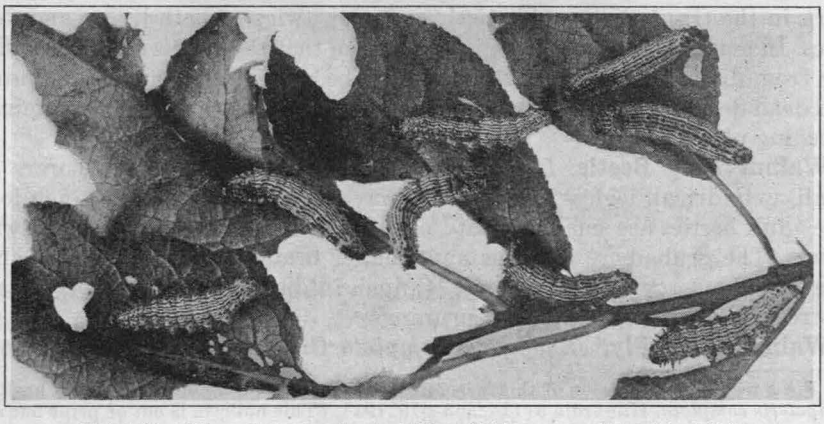


Fig. 157.—The red-humped caterpillar, *Schizura concinna* (A. & S.).

Fruit Tree Leaf Roller, *Tortrix argyrospila* (Walk.) (*Archips*).—Much like the codling-moth larva, the larva of this insect occasionally attacks nuts in the same way, but the chief injury is due to feeding on leaves. Only occasionally is it of importance. This larva, when mature, is not of a pinkish color like that of the codling moth. No satisfactory control is known.

Indian-Meal Moth.—See under "Dried Fruits" (p. 65) and "Nuts in Storage" (p. 87).

Mediterranean Flour Moth.—See under "Dried Fruits" (p. 65) and "Nuts in Storage" (p. 87).

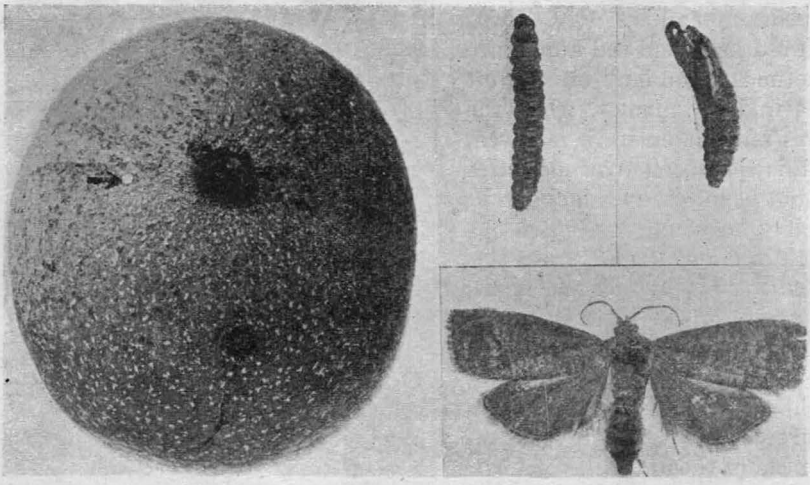


Fig. 158.—The codling moth, *Carpocapsa pomonella* (Linn.), and injury to green walnut caused by the larva. Arrow indicates egg. (Greatly enlarged.)

Nautical Borer, *Xylotrechus nauticus* (Mann.).—The borers are fleshy, white or yellowish-white grubs, slightly enlarged at the anterior end, and about ¾ inch long. The adult beetles are ½ inch long, dark, with narrow, broken, whitish or grayish, wavy cross bands on the wing covers. The larvae work in the trunk, limbs (fig. 159), and even twigs of both living and dead trees. In general, their presence is a symptom that the tree is sickly or suffering from disease. Infested portions should be cut out and burned. Prunings and dead deciduous trees in the neighborhood should be destroyed to eliminate breeding places.

Walnut Twig Beetle, *Leptidiella brevipennis* (Muls.).—The borers are small, cylindrical, legless, white or creamy-white grubs about ¼ inch long. The adult beetles are small, delicate, and somewhat wasplike, with short wing covers. The grubs bore in twigs and smaller branches. Infested twigs show small, oval emergence holes, about 1/16 inch in diameter. To control, cut and destroy infested twigs and burn prunings.

Walnut Husk Fly,[37] *Rhagoletis completa* Cress.—The adult is shown in

[37] For a technical discussion of this insect, see: Boyce, A. M. Bionomics of walnut husk fly, *Rhagoletis completa*. Hilgardia 8(11):363–579. 1934. (This bulletin is out of print but may be consulted in many city and county libraries in California.)

figure 160. Irregular blackened areas in the husk in the late summer and fall indicate the work of the larva or maggot. The injury, which is most common

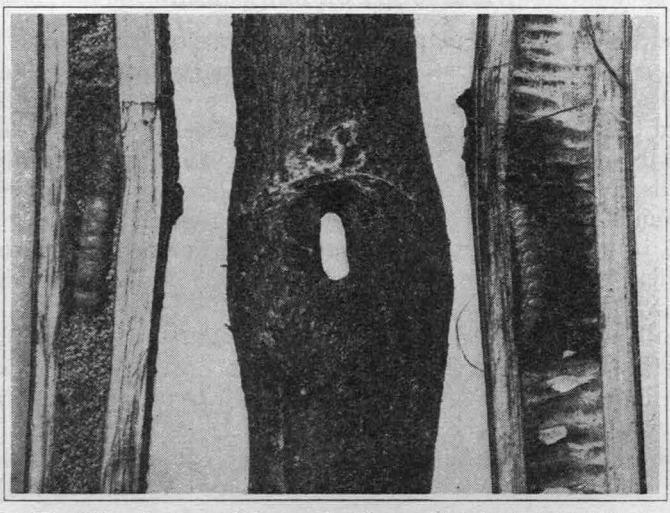


Fig. 159.—Larvae of the nautical borer, *Xylotrechus nauticus* (Mann.), in small limbs of the walnut.

in the late-maturing, thick-husked varieties, is due to the black stain on the shell beneath the feeding tunnels. To control, spray with cryolite (formula 5,

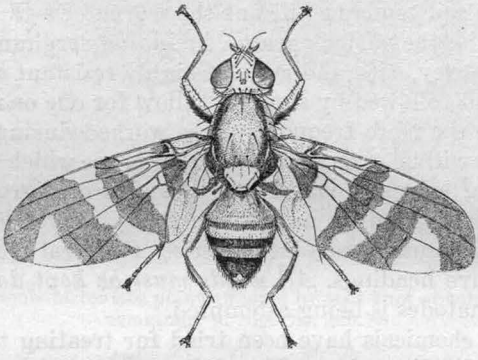


Fig. 160.—The walnut husk fly, *Rhagoletis completa* Cress. (Greatly enlarged.) (From Cir. 315.)

p. 161) at the time determined by bait traps (formula 36, p. 182) and follow 1 month later with cryolite dust plus oil (formula 7, p. 161).

WATERMELONS

(See "Melons," p. 83)

GENERAL SUBJECTS

NEMATODES, OR EELWORMS[38]

Nematodes which attack plants are small worms scarcely visible to the eye which enter or attach themselves to different parts like roots, stems, buds, bulbs, or leaves, and continue their existence there in the living tissue. The presence of these parasites either kills the part affected or causes the development of galls, swellings, and other abnormal growths and eventually weakens or even kills the host plant. . . . Nematodes reproduce by means of eggs, which become abundant in diseased plant parts and in infested soil. The eggs average about $\frac{1}{250}$ inch in length and hatch into young worms of a length of about $\frac{1}{32}$ inch [fig. 162]. These again attack plants when favorable conditions and hosts are available.

The root-knot or common garden nematode, *Heterodera marioni* Cornu,[39] causes swellings or galls on the roots of a great many different kinds of plants [fig. 161], including most annual crops, fruit trees, ornamentals, and many weeds. The worms are imbedded in these galls, the largest form being the adult female, which has a white pearl-shaped body the size of a small pinhead.

The sugar-beet and citrus-attacking species are very similar to the garden nematode; leaf-, bulb-, and stem-attacking nematodes of a number of species occur commonly, especially on alfalfa, begonia, gooseberry, narcissus, strawberry, and other hosts.

Although a great deal of work has been done in many parts of the world in trying to find some way of controlling root-knot nematodes, no practical method has been found except to starve out the worms by growing some unsusceptible crop or keeping the land clear of all vegetation for one or more years. Drying the soil tends to kill out the worms. Of the crops commonly grown in California, the various grains, including sorghum, milo, and kafir, as well as wheat, barley, oats, and rye, are highly resistant and may be grown as winter crops and followed by summer fallow for one or more seasons. The dryer the soil and the more frequently it is worked during the summer, the quicker the worms will be exterminated. Other crops which may be grown are certain varieties of cowpea (consult the Division of Agronomy, College of Agriculture, Davis, regarding names and seed), velvet bean, sweet clover (*Medicago*), and peanuts. Resistant varieties of several crops are mentioned under the respective headings. *All weeds must be kept down* whenever the eradication of nematodes is being attempted.

Many different chemicals have been tried for treating the soil to destroy nematodes. Newhall[40] lists about fifty different materials which have been experimented with for this purpose. None of them has proved to be of practical value, either on account of poor efficiency, injury to crops, or prohibitive cost. Miss Tyler [see footnote] discusses this phase of the subject in detail and

[38] This section is quoted from: Smith, Ralph E. Diseases of truck crops. California Agr. Ext. Cir. 119:94–97. 1940.

[39] For further information see: Tyler, Jocelyn. The root-knot nematode. California Agr. Exp. Sta. Cir. 330:1–34. 1933. (Revision in press.)

[40] Newhall, A. G. Control of root-knot nematode in greenhouses. Ohio Agr. Exp. Sta. Bul. 451:1–60. 12 figs. 1930.

states that the most promising of these substances are carbon disulfide and chloropicrin. In greenhouse soils these or some other chemical may have some possible value, but effective and practical methods of application have not yet been developed.

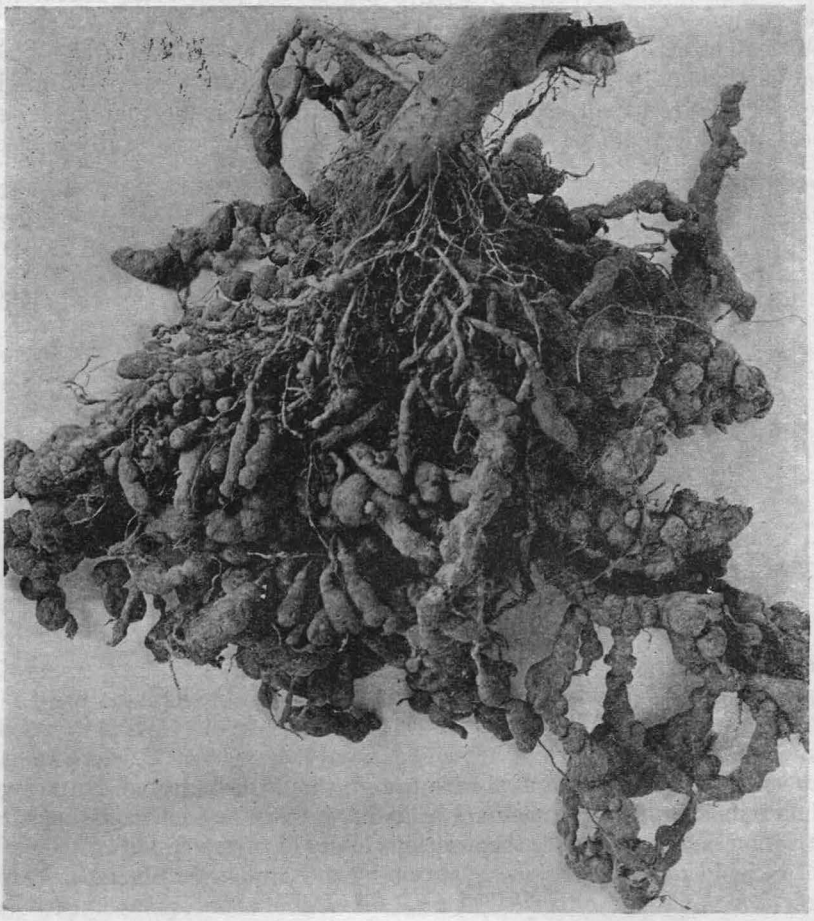


Fig. 161.—Roots of tomato plant affected by root-knot or common garden nematode. (From Cir. 280.)

The leaf and bud nematode, *Aphelenchoides fragariae* Ritzema-Bos, lives in the fleshy foliage tissue of plants like begonia, dahlia, and gloxinia (no important truck crops are attacked), and produces large dead areas in the leaves. The only way of controlling this pest is to discard or disinfect with steam all soil, pots, benches, and other material with which affected plants have been associated. Such diseased plants should be destroyed by burning.

The bulb or stem nematode, *Ditylenchus dipsaci* (Kühn) [fig. 162], also lives in the tissues of affected plants of many different species, like strawberries, alfalfa, garlic, narcissus, and phlox. In this case, however, many of

the host-plant species have distinct strains or races of the parasite, so that the worms from narcissus, for instance, will not attack the strawberry, even though they are of the same species.

In greenhouses, nematodes of all types must be handled by destroying affected plants and steam-sterilizing infested soil, pots, beds, benches, and other equipment or replacing with fresh material.

With all crops or plants which are known to be subject to nematode attacks, great care should be taken to guard against introducing these pests into new places. They are usually spread on nursery stock, growing plants, or bulbs, tubers, or other plant parts. All such material should be carefully inspected

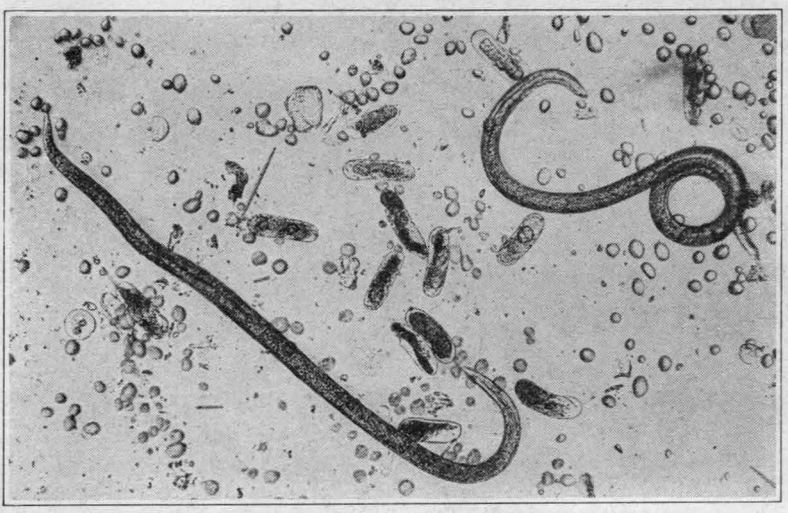


Fig. 162.—The bulb stem nematode, *Ditylenchus dipsaci* (Kühn), with young worms and eggs. (Greatly enlarged.) (From Ext. Cir. 118.)

for nematodes and, if symptoms are found, should be rejected. Nurserymen and florists should be particularly careful in this respect, since nematode infestation is likely to cause them serious losses in rejected stock.

SLUGS AND SNAILS[41]

Slugs and snails are not insects, but are mollusks, which include animals such as clams, mussels, and oysters.

The slugs are close relatives of the snails but have the shell reduced and located internally so that they are devoid of external protection. One California slug (*Testacella* sp.) has a posteriorly located external shell and is predaceous on earthworms. The enormous native yellow slugs (*Agriolimax*),

[41] Additional information on these pests will be found in:

Basinger, A. J. The European brown snail in California. California Agr. Exp. Sta. Bul. 515:1–22. 1931. (This bulletin is out of print but may be consulted in many city and county libraries in California.)

Lange, W. H., Jr. The artichoke plume moth and other pests injurious to the globe artichoke. California Agr. Exp. Sta. Bul. 653:1–71. 1941.

Lange, W. H., Jr., and G. F. MacLeod. Metaldehyde and calcium arsenate in slug and snail baits. Journal of Economic Entomology 34(2):321–22. 1941.

which occur throughout the coastal and mountainous regions of the state and on certain islands off the coast of southern California, occasionally are reported as damaging garden vegetables, but seven introduced species are the chief offenders: (1) the spotted slug (*Limax flavus* Linn.), greenish-brown, with spots of lighter yellow, with bluish head and tentacles, often from 3½ to 4 inches long, with conspicuous yellow slime; (2) the large gray slug or giant slug (*L. maximus* Linn.), light gray with large irregular black spots, ranging from 4 to 8 inches long, with clear and uncolored slime; (3) the small striped slug (*L. marginatus* Müller) occurring chiefly as a pest in lawns, light brown with gray or black bands, the immature forms being more distinctly banded; (4) the gray garden slug (*Deroceras agreste* [Linn.]) (fig. 163), the commonest slug, very destructive to vegetables and field crops, buff to gray in color with varying irregularly placed black spots, from 1½ to 2 inches long,

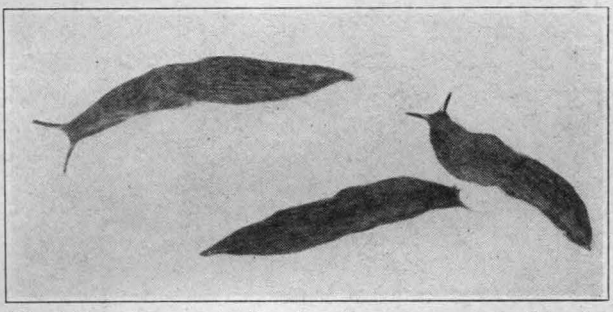


Fig. 163.—The gray garden slug, *Deroceras agreste* (Linn.). (Natural size.) (From Bull. 653.)

with milky slime when irritated; (5) the long-necked slug (*D. laeve* [Müller]), with an orange-brown spot with scattered blackish spots on mid-part of body (mantle), the rest of the body brown to grayish, the neck very long when extended, from 1½ to 2 inches long, the slime clear; (6) the gray field slug (*Deroceras gracile* [Raf.]), common in lawns and fields, the color varying from a uniform buff to black, from ¾ to 1 inch long, with clear slime, and with very rapid movement; and (7) the greenhouse slug (*Milax gagates* Drap.), a widely distributed, very destructive slug, uniform black to dark gray, with a conspicuous longitudinal ridge down the top of the body and a distinct diamond-shaped mark on center part of body (mantle), 1½ to 3 inches long. Eggs of the last species are shown in figure 164.

Slugs are active chiefly by night and seek shelter by day in crevices in the ground and under boxes, stones, or other cover on the ground.

Control of slugs consists in the removal of daytime refuges, the use of contact and repellent mixtures, and the use of poison baits. Dusting the ground and bases of infested plants with a mixture of 20 per cent monohydrated copper sulfate and 80 per cent hydrated lime has proved effective as a contact poison and repellent mixture. The use of a bait with metaldehyde and calcium arsenate as the active ingredients will give satisfactory control if used when the slugs are active and if several applications are made. A most satisfactory mixture is given on page 180 (formula 29). This mixture is

applied as a wet mash, broadcast or placed in piles near the plants. Best results are obtained if the baits are put out toward evening at times when the slugs are active. Since metaldehyde is difficult to obtain at present, the home gardener or grower may have to use the bait without it.

The European brown snail, *Helix aspersa* Müller, is well known to home gardeners. This large brown snail with darker shell bands feeds on many plants, shrubs, and trees, and is often responsible for serious injury. Control is by hand-picking, destruction of daytime resting places, and the use of poison baits. The use of a bait as recommended for slugs (formula 29, p. 180) will

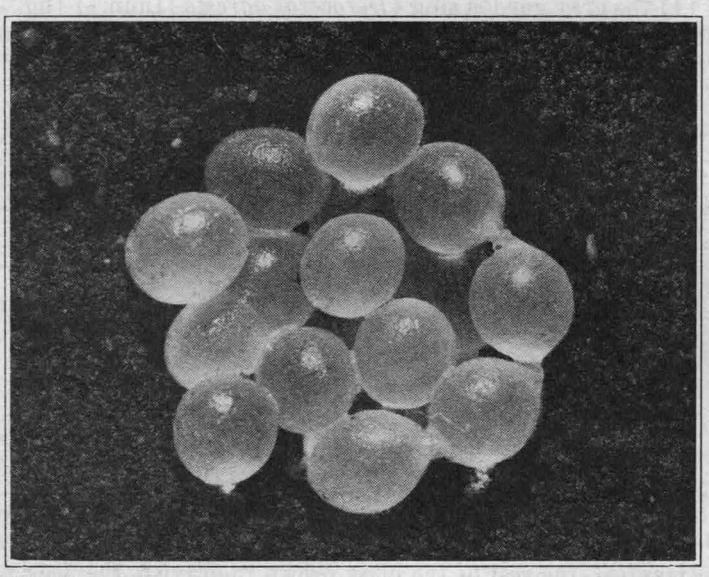


Fig. 164.—Egg mass of the greenhouse slug, *Milax gagates* Drap. (Five times natural size.) (From Bul. 653.)

give good results; or in place of a portion of the bran, 40 per cent of raisins or orange rind can be added. Good control of snails may often be obtained by omitting the metaldehyde.

Several other snails have been introduced into the state and their eradication is being attempted. These include the white snail (*Theba pisana* [Müller] [*Helix pisana* Müller]) *Helix aperta* Müller, milk-white snail (*Helix lactea* Müller), and banded wood snail (*Cephaea nemoralis* [Linn.]). Several native snails of the genus *Helminthoglypta* occasionally invade gardens and feed on vegetables in certain coastal localities.

SOWBUGS AND PILLBUGS[42]

Sowbugs (fig. 165) and pillbugs are small flattened animals ¼ to ⅜ inch long with many legs, occurring in damp situations and largely nocturnal in habit. The principal species involved are the common pillbug (*Armadillidium*

[42] Dr. R. M. Bohart contributed to this section.

vulgare [Latreille]), the dooryard sowbug (*Porcellio laevis* Koch), and the scabby sowbug (*Porcellio scaber* Latreille). Pillbugs, which are able to roll up into a ball, are the commonest of those mentioned and the most destructive. These animals are pests in gardens, lath-houses, and greenhouses, especially to seedlings, and may cause injury under field conditions. Pillbugs overwinter as adults. They breed from March to October, with two generations annually under field conditions. In the greenhouse they breed continuously. Sowbugs breed more rapidly, but their active period is similar to pillbugs.

Control of sowbugs and pillbugs can be accomplished through use of a mixture of 5 pounds of calcium arsenate and 2 pounds of white flour, applied with a small dust gun thinly over the surface of infested ground at the rate of 5 pounds per 1,000 square feet. Baits are not always satisfactory, but a limited degree of control can be obtained through the use of a poison bran mash made by mixing together, dry, 1 pound of wheat bran and 1 ounce of paris green, which are then sweetened and moistened to the consistency of a mash by using 2 tablespoons of blackstrap molasses diluted in 1 pint of water. This bait is sown broadcast throughout the garden or placed in small portions under boards or inverted flower pots filled with straw, where the sowbugs collect. It may also be used in greenhouses, but what appears to be more satisfactory under glass is a poison composed of 5 parts of granulated or brown sugar and 1 part of paris green, mixed dry and placed on small wooden or tin plates throughout the beds, or poured on the frames of the beds of the greenhouse. This bait can be used outside also if protected from the rains and excessive soil moisture.

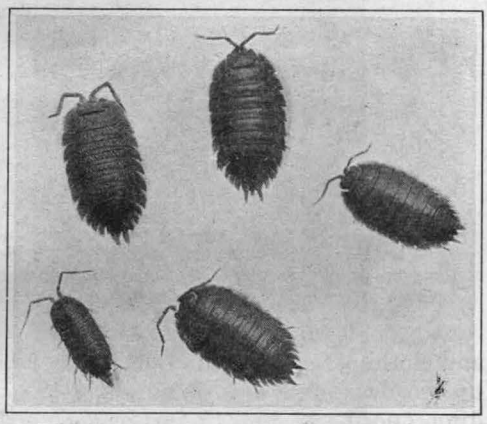


Fig. 165.—Sowbugs, *Porcellio laevis* Koch and *P. spinicornis* Say. (Slightly enlarged.) Pillbugs are species of sowbugs which roll up into a ball when disturbed.

It is, perhaps, wise to offer a word of caution regarding the use of a bran bait where poultry may pick it up and the use of sugar and paris green in places frequented by children. See also remarks on the danger of using poison baits on vegetables, under "Armyworms and Cutworms" (p. 144).

EARWIGS

Earwigs, especially the European earwig, *Forficula auricularia* Linn. (fig. 166), are nuisances in the gardens and houses in some parts of the state. They are usually nocturnal, dark brown or blackish insects, ½ to ¾ inch long, with conspicuous pincers at the posterior end, as shown in figure 166. At times they feed extensively upon growing vegetables, flowers, and ornamental plants and may do considerable damage to them. They also feed on foodstuffs in the house and are offensive to have around since they hide under rugs, in shoes

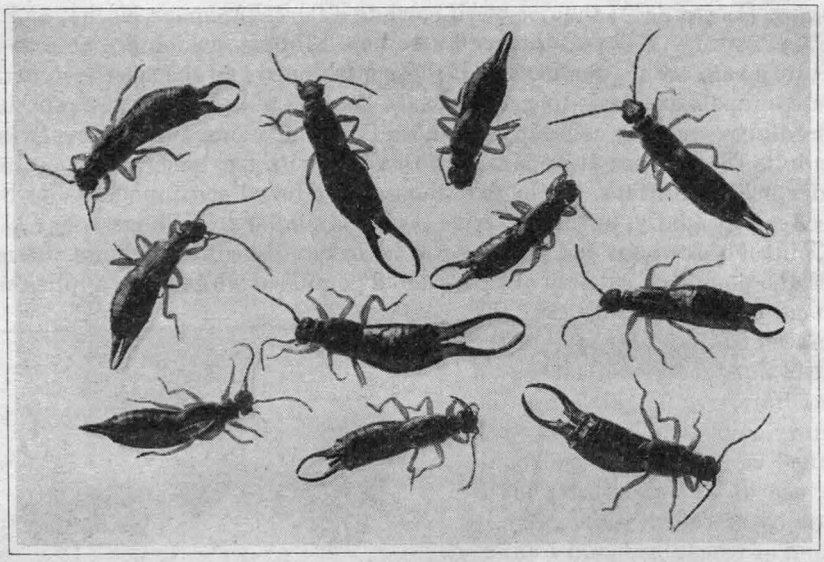


Fig. 166.—The European earwig, *Forficula auricularia* Linn. The males have the curved anal forceps. (1½ times natural size.) (After Essig, *Insects of Western North America*, by permission of the Macmillan Co., copyright owners.)

and clothing, and in and under many household objects. They are controlled by broadcasting a bait composed of 12 pounds of wheat bran, 1 pound of sodium fluosilicate, and 1 quart of fish oil thoroughly mixed together (formula 30, p. 180).

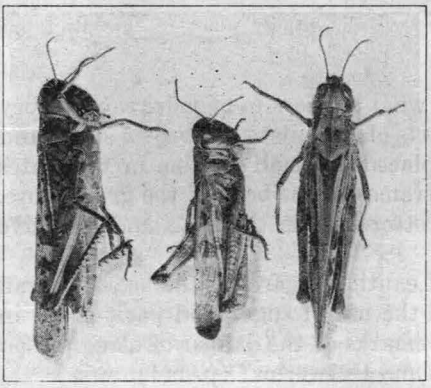


Fig. 167.—The clear-winged or pellucid grasshopper, *Camnula pellucida* (Scudd.), a pest in many parts of the state.

GRASSHOPPERS

To control grasshoppers, scatter poison bran mash or citrus bran mash freely (formula 27 or 28, p. 179). Be sure to mix the bran and poison thoroughly. Scatter in alfalfa fields about 4 o'clock in the afternoon and around orchard trees or other plants early in the morning. Concerning the danger of using poison baits on vegetables see "Armyworms and Cutworms" (p. 144). A common species of grasshopper in this state is shown in figure 167.

MEALYBUGS

In California, mealybugs, *Pseudococcus* spp., are among the most serious enemies of many native and introduced plants, particularly subtropical fruits and ornamental flowering plants and shrubs. They infest all parts of the plants, including the roots, branches, leaves, flowers, and fruits, and often

collect in compact colonies and deposit their eggs in masses of cottonlike waxy material, which are most evident in late summer, fall, and winter.

The newly hatched insects are yellowish and very minute—just visible to the naked eye. As they grow they become covered with a whitish, powdery wax which extends as short rods around the margins of the body, and as longer filaments or tails posteriorly (fig. 168). The shape and length of these pos-

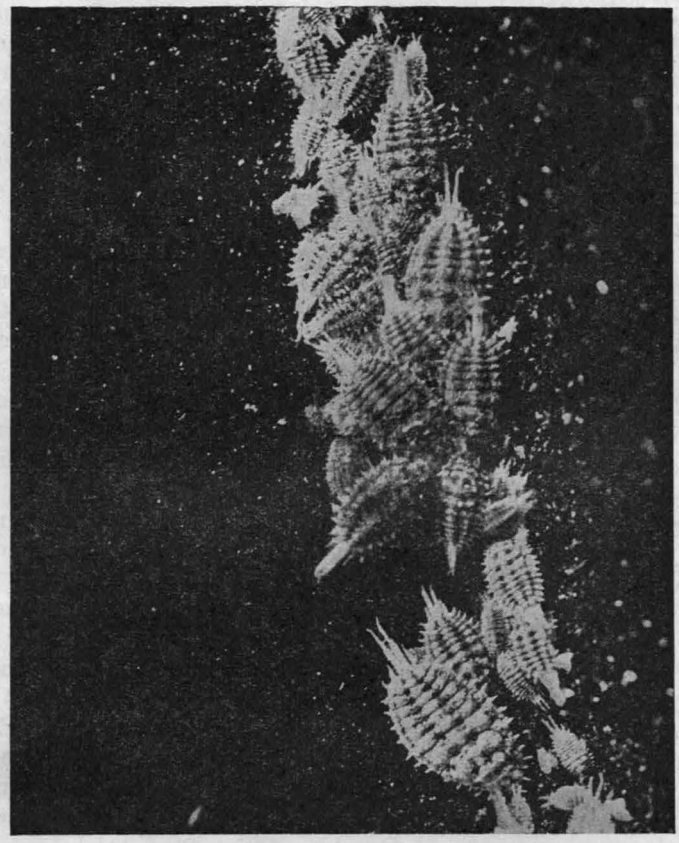


Fig. 168.—The citrophilus mealybug, *Pseudococcus fragilis* Brain, a common pest of fruit, garden, and ornamental trees, shrubs, and plants. (Greatly enlarged.)

terior filaments are useful in distinguishing the various species. The white waxy covering is responsible for the common name, mealybug. The males are minute, two-winged insects, which are often seen hovering about the infested plants during the late afternoons and evenings in the fall of the year.

Mealybugs, like many other scale insects and like aphids, excrete quantities of honeydew, which cover the infested plants like a thin coating of sirup. In cool and temperate areas, such as the coastal region of this state, a black-smut fungus grows on the honeydew, which is responsible for the dirty, smutty appearance of plants infested with these insects. To eliminate the smut, it is

necessary to get rid of the mealybugs or other insects which produce the honeydew. Ants are fond of this sweet excrement and protect the mealybugs to insure a constant supply of it. Therefore, in connection with mealybug control, it is always advisable to control the ants as well, using the poisons as recommended (formulas 33 and 34, p. 181). See "Ants" (p. 151).

Mealybugs are difficult to combat, owing to the protection afforded by the white waxy covering and their habits of collecting in dense colonies, depositing their eggs in large cottony masses, and feeding also underground. In the citrus orchards of southern California and in the vineyards of some parts of the Sacramento and San Joaquin valleys, ladybird beetles and minute parasites have been reared and liberated at a considerable cost to the growers, but often with much effectiveness. The San Francisco Bay region, however, appears to be too cool in certain sections for these natural enemies to thrive, so that it is necessary to resort to sprays. A spray program recommended for mealybugs is given below.

Spring and Summer Control. -Thoroughly hose off the infested plants with a nozzle and as strong water pressure as is available. Hosing alone will sometimes control mealybugs. Spray shortly afterwards with any of the highly refined commercial oil emulsions at a dilution of from 2 to 3 per cent or as indicated by the manufacturer, or 1½ to 2 per cent tank mix (see p. 167). Use as much force as possible and a coarse driving spray. Repeat applications of sprays every week until satisfactory control is obtained. Two or three applications may be necessary. Remove soil about the roots; pour in a quantity of the diluted spray to kill mealybugs on the roots.

Irrigate infested plants a day or so before spraying them, because plants suffering for want of water are very susceptible to spray injuries, especially when oil emulsions are used.

Soap and nicotine sprays are of little value unless used in combination with oils. Homemade mixtures are likely to injure tender plants.

Winter Applications.—Dormant deciduous plants may be sprayed with any of the winter oil sprays (for example, formula 10, p. 165) or with emulsive oil (3 per cent), or commercial oil sprays (5 per cent). Evergreen plants may be sprayed during the winter with the summer oils or more highly refined miscible oils and other oil emulsions. Winter mixtures may also be used on the hardier plants. In other respects, conform to the recommendations given above.

ARMYWORMS AND CUTWORMS

General Life History.—The adults, millers or moths (fig. 169), of members of the family Noctuidae are practically all night-flyers. The caterpillars of many are known as armyworms and cutworms (fig. 170) and are among the most destructive of insect pests. They often advance from field to field in great numbers, like an army, devastating as they go. Like the grasshoppers, they attack practically all kinds of plants, including field and truck crops, vineyards and orchards, flowers, and weeds.

The adults lay their eggs (fig. 171) in spring and summer; and the larvae may become exceedingly numerous from early summer to fall, when most of the damage is done. The pupae and larvae hibernate. Hibernating larvae often seriously injure grapevines in the spring by eating the buds. (See also p. 4.)

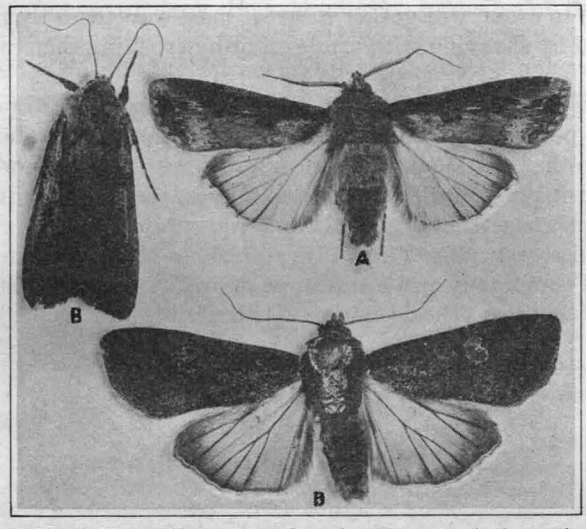


Fig. 169.—Millers, or moths, of cutworms: *A*, the variegated cutworm, *Lycophotia margaritosa* (Haw.); *B*, the reaper dart, *Euxoa messoria* (Harris). (Slightly enlarged.) (After Essig, *Insects of Western North America*, by permission of the Macmillan Co., copyright owners.)

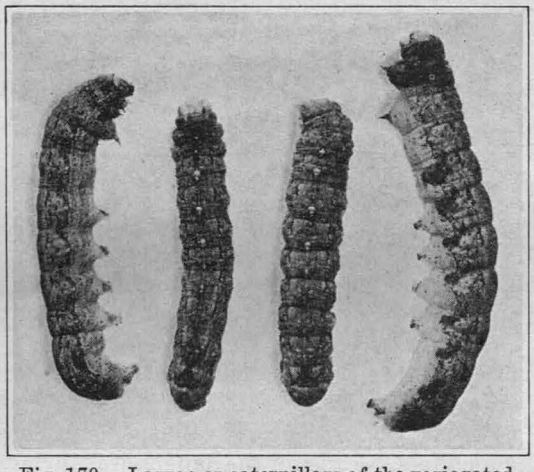


Fig. 170.—Larvae or caterpillars of the variegated cutworm, *Lycophotia margaritosa* (Haw.).

Control.—The control of these insects has been a difficult problem for years, and even today the methods worked out do not always give relief.

Clean culture in fall and thorough plowing of infested fields to kill the hibernating pupae in the cells is supposed to reduce the next year's broods greatly. This has been recommended as especially important in pea fields and gardens.

When the worms begin to march, trenches may be plowed across and ahead of their paths with a perpendicular wall in front of the advance. The worms,

not being able to cross, will gather in great masses in these trenches and can be easily killed by spraying with crude oil or by crushing them with a narrow disk or roller.

Arsenical or fluosilicate sprays or dusts including 15 to 25 pounds of calcium arsenate per acre or a 50 to 70 per cent cryolite dust, applied preferably when dew is on the plants, as soon as the larvae begin to appear, will sometimes materially aid in protecting crops like potatoes, tomatoes, young trees, and grapevines, but are seldom practical for forage crops.

Poisoned baits (formulas 27, p. 179, and 31, p. 180), sown in the infested fields, will kill countless worms, and these afford by far the most satisfactory means of killing these insects under all conditions. In fields, pastures, or-

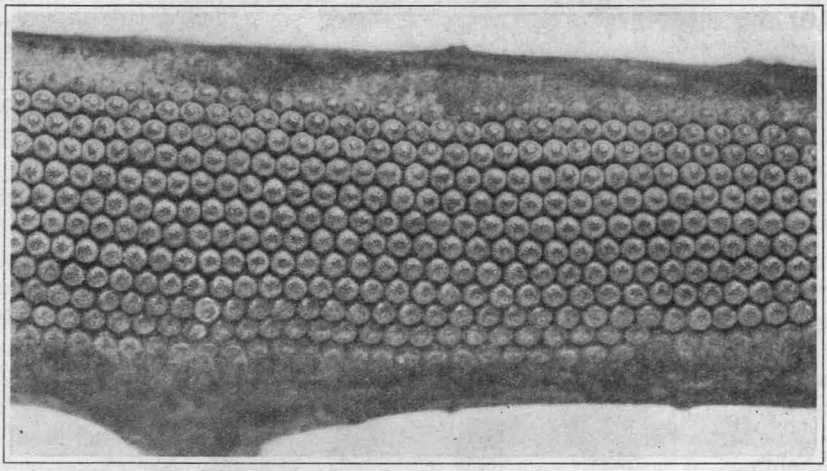


Fig. 171.—The eggs of the variegated cutworm, *Lycophotia margaritosa* (Haw.), laid on the branch of a fruit tree. (Greatly enlarged.) (After Essig, *Insects of Western North America*, by permission of the Macmillan Co., copyright owners.)

chards, and gardens, the poisoned baits may be thinly sown over the plants. The armyworms and cutworms will eat the bait in preference to growing vegetation.

Attention must be called to the fact that great care should be exercised in applying poison sprays and baits to the foliage of plants consumed as greens and such others as asparagus, artichokes, cabbage, cauliflower, lettuce, turnips, and ripening tomatoes, because of the danger of injuring consumers, who may be unaware of the presence of such poisons on the vegetables. Therefore, avoid the use of such materials except on young plants before the edible portions are formed. Under no condition should such insecticides be applied on nearly mature or mature plants or edible parts. In many cases the poison bait may be scattered between the rows away from the plants.

Light traps are also used to capture the adults, but have never seemed to lessen the attacks greatly, because large numbers of the moths captured have previously laid their eggs.

Natural Enemies.—By far the most important factors in the control of armyworms and cutworms are natural enemies. The parasitic tachinid flies

kill countless numbers of them. Hymenopterous parasites of the family Ichneumonidae also prey upon the young. The predaceous ground beetles of the family Carabidae devour the worms and destroy great numbers. That armyworms and cutworms are not injurious every year is undoubtedly because of the work of these natural enemies.

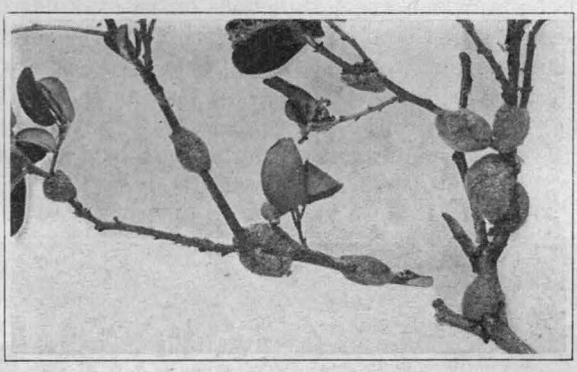


Fig. 172.—The egg masses of the Great Basin tent caterpillar, *Malacosoma fragilis* (Stretch). They encircle the small twigs and are enclosed in a cementlike matrix. These eggs are laid in summer and hatch early the following spring.

Fig. 173.—The forest tent caterpillar, *Malacosoma disstria* Hbn.: a group of mature caterpillars resting on a silken webbed nest on an apple limb.

TENT CATERPILLARS

The most important species occurring in California are the California tent caterpillar (*Malacosoma californica* [Pack.]), the blue-sided tent caterpillar (*M. constricta* [Stretch]), the forest tent caterpillar (*M. disstria* Hbn.), the

Great Basin tent caterpillar (*M. fragilis* [Stretch]), and the coast tent caterpillar (*M. pluvialis* [Dyar]).

The gray or brown, hairy caterpillars known as tent caterpillars (fig. 173) have a row of white spots on the back or pale bluish lines on sides, and are from 1 to 3 inches long. They live either in compact colonies or in tightly woven webs or tents, which are conspicuous on many kinds of trees in the spring of the year. Entire colonies may be exterminated by cutting off infested branches and burning them, or by burning them on the tree with a torch, or by dusting infested portions with powdered lead arsenate. The small, dark egg masses (fig. 172), encircling the smaller limbs, may be pruned out and burned when the trees are dormant. Spraying with lead arsenate (formula 1 or 2, p. 156) will control the caterpillars effectively.

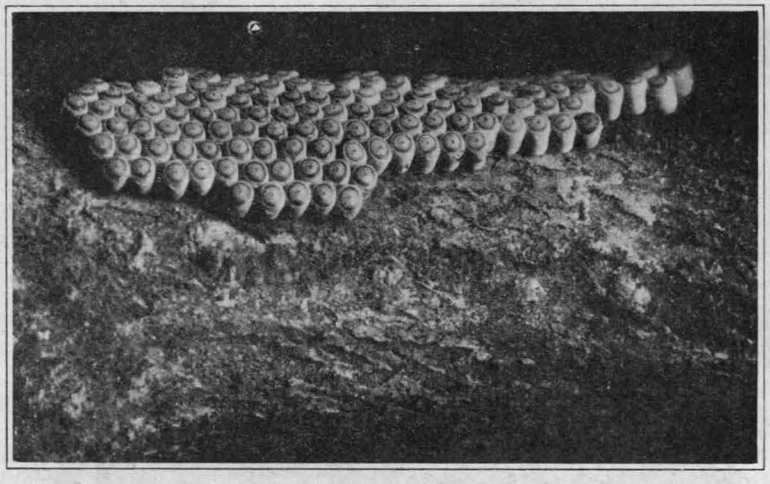


Fig. 174.—Eggs of the fall cankerworm, *Alsophila pometaria* (Harris), on prune tree. (Fifteen times natural size.)

CANKERWORMS, SPANWORMS, LOOPERS

The important California species are the fall cankerworm (*Alsophila pometaria* [Harris]), the spring cankerworm (*Paleacrita vernata* [Peck]), the walnut spanworm (*Coniodes plumogeraria* [Hulst]), and the omnivorous looper (*Sabulodes caberata* Guénée).

Cankerworms are small, green or dark measuring worms less than an inch long, which feed upon the leaves and young fruit and drop down on a silken thread when the tree is jarred. The females are wingless and crawl up the trees in the fall or spring to lay their eggs on the limbs and small branches. Egg-laying on the trees (figs. 174 and 176) is prevented by placing Tanglefoot, Deadline, cotton, or permanent wire-screen bands around the trunks of the trees in the fall in order to catch both the fall and spring worms. The caterpillars (fig. 175) are easily jarred from the trees, but will crawl up again if not obstructed. Spraying with lead arsenate (formula 1 or 2, p. 156) will also give control. Pyrethrum dusts and commercial pyrethrum extracts di-

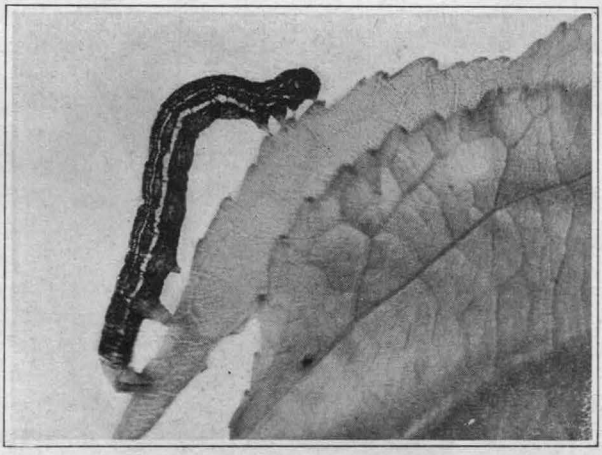


Fig. 175.—Larva or caterpillar of the fall cankerworm, *Alsophila pometaria* (Harris).

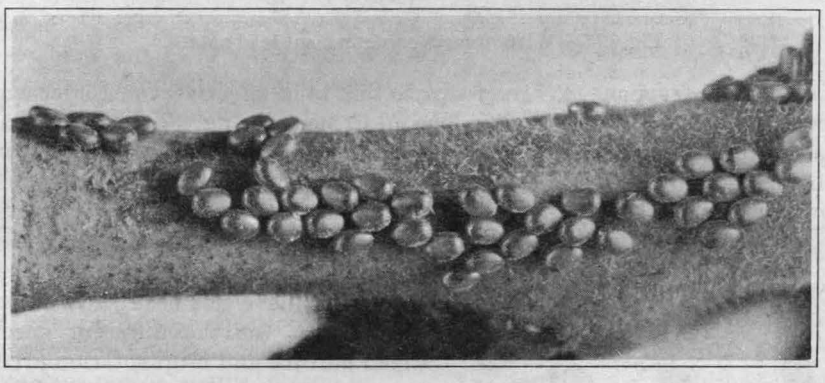


Fig. 176.—Eggs of the walnut spanworm or cankerworm, *Coniodes plumogeraria* (Hulst), on prune. (Fifteen times natural size.) The insect often occurs on walnut also.

luted 1 part to 300 parts of a 1 per cent light oil emulsion have given remarkably good results in the control of these insects.

WIREWORMS

The commonest injurious wireworms in California are *Aeoleus livens* (Lec.), ash-colored elater (*Anchastus cinereipennis* [Esch.]), dusky click beetle (*Cardiophorus tenebrosus* Lec.), sugar-beet wireworm (*Limonius californicus* [Mann.]), gray elater (*L. canus* Lec.), dusky wireworm (*L. infuscatus* Mots.), long elater (*Melanotus longulus* [Lec.]), and Oregon wireworm (*M. oregonensis* [Lec.]).

Wireworms get their name from their smooth, round bodies, which are usually shiny, varying in color from pale yellow to dark brown. The common injurious forms are about 1 inch long. They live in the soil, preferring sandy loams rather than heavy soils, although they may be found in either. The lar-

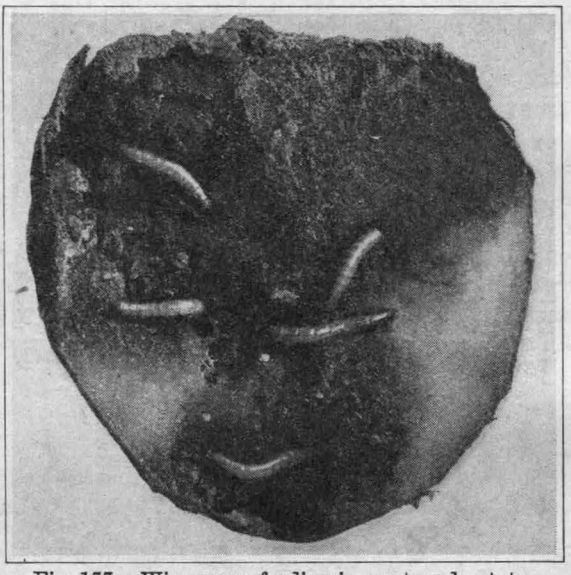


Fig. 177.—Wireworms feeding in a cut seed potato.

val stages last from one to three years, so that to be effective, control measures must cover the maximum period. The adult beetles (fig. 178) are known as "elaters" or as "click beetles" because of their ability to jump in the air with a clicking sound. They are mostly inconspicuous beetles of various shades of brown or entirely black, about ½ inch long. They are active and fly freely.

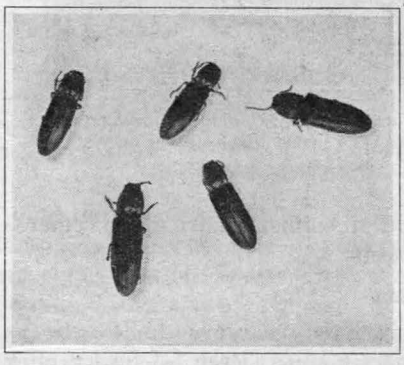


Fig. 178.—Click beetles, adults of the wireworm, *Limonius californicus* (Mann.), small dark-brown beetles about ½ inch long.

Control measures are difficult because of the underground habits of the larvae, and as yet have not been satisfactorily worked out for the different species. Clean culture and crop rotation are the most reliable practices, and much good comes from thorough cultivation. Trapping the adults with small piles of straw and burning them in fall and winter destroys large numbers, Replanting is often necessary with many crops, such as potatoes, beans, peas, and melons. A teaspoon of paradichlorobenzene in the soil near dahlia or potato tubers (fig. 77, p. 64, and fig. 177) and bulbs has given very good protection; but if it is used excessively, burning and injury result.

ANTS[43]

Ants affect man in many different ways. They may invade the home and destroy or damage various food materials or become obnoxious by their very

[43] For further information, see: Eckert, J. E., and Arnold Mallis. Ants and their control in California. California Agr. Exp. Sta. Cir. 342:1–39. Revised 1941.

presence. They invade the lawn, garden, and field, and destroy plants and seeds by different means. They care for aphids and various scale insects, which in turn do an increasing amount of damage to trees and other plants. Certain forms even damage trees and timbers by constructing cavities or enlarging existing ones.

The life history of ants is fairly similar in the different species, so that each need not be considered separately. Ants lay eggs which hatch into legless larvae that have to be fed and cared for by the adults. The length of the feeding period varies greatly with environmental conditions; it may cover an interval of from 2 to several weeks. The larvae change into pupae, which may be naked or encased in cocoons, according to the species. The pupae change into adults which are limited by size and structure to specific types of activities. The developmental stages occur in numerous situations typical of the different species, such as in soil, under leaves, bark, stones, or wood, or in cavities of trees and other sheltered places.

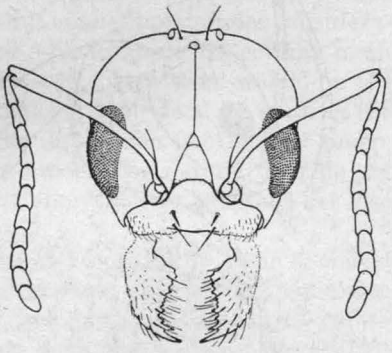


Fig. 179.—Head of Argentine ant, *Iridomyrmex humilis* Mayr, showing the characteristic arrangement of the teeth and the elbowed antennae. The small eyes at the top of the head distinguish the queen from the worker. (From Bul. 207.)

The efficient control of ants is based on a knowledge of the nesting and food habits of the offending species. If the nests can be located, the entire colony may be killed by various fumigants, such as carbon disulfide, carbon tetrachloride, or calcium cyanide. Oil can be used as a contact killing agent, and oil sprays in which small quantities of pyrethrum and rotenone are incorporated are likewise effective. Argentine ants may be flooded out of their nests by irrigation and then all inmates killed with a contact spray.

Various poison sirups, poison baits, and ant powders are sold on the open market, many of which are effective under favorable conditions. The sirups generally are made like formula 33 or 34 (p. 181) and contain sufficient poison in the sirup to enable the ants to carry it back to their nests, where it kills those to which it is fed. For grease-eating ants, small quantities of sodium arsenite are mixed with fats and made accessible to the pests. Ant powders, usually combinations of pyrethrum, rotenone, and sodium or barium fluosilicate, are useful in killing ants and in forming barriers over which ants cannot pass.

Ant poisons should be handled with care, and containers should be well labeled and placed beyond the reach of children. Small pieces of sponge can be saturated with the liquid poison and placed in a perforated container with a lid too tight for children to remove. Small glass jars with holes punched in the lids may be used instead of cans; if the lids are screwed on tightly they are less likely to be opened by children. Containers should be placed outside the home where ants can be seen to enter, rather than in the kitchen. Poison cans should be replenished frequently and moved to new locations when ants no longer frequent them.

The Argentine ant (figs. 179 and 180), as well as other species, frequently fosters and protects various scale insects in the orchard, and ant control is therefore highly desirable. The same arsenical formulas are recommended as for house-infesting forms, and the perforated cans or other containers may be fastened to the trees so as not to interfere with cultivation or irrigation.

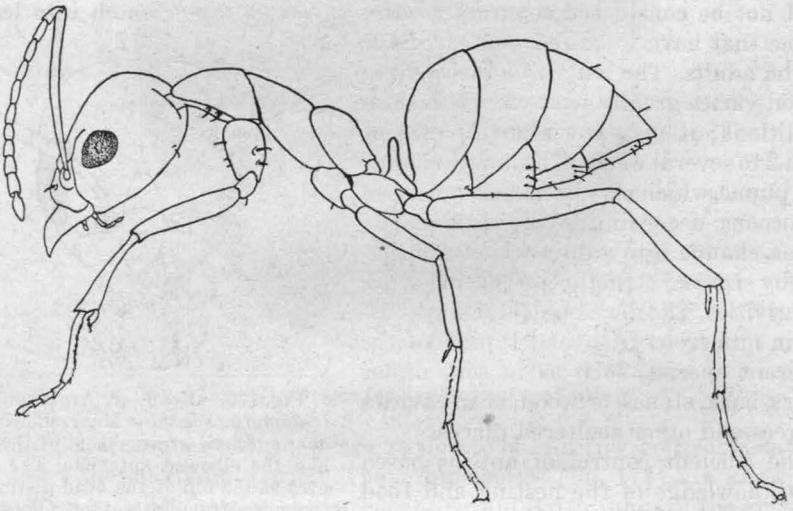


Fig. 180.—The Argentine ant, *Iridomyrmex humilis* Mayr. (Greatly enlarged.) This is the most important ant pest in California. (From Cir. 342.)

THE CHEMICAL CONTROL OF INSECTS

Many potential insect pests are kept in check by unfavorable environmental conditions, natural enemies, the development of resistant crops, and other such measures. But very often this "natural control" is ineffective, and recourse must be had to "artificial control" through the use of poisonous chemicals. In fact, insecticides may be called man's last line of defense in his conflict with the multitude of insects which constantly devour his food, incapacitate his animals, and destroy his own health and peace of mind. While chemicals have been used in combatting insects for many years, it is only within the last three generations that a scientific understanding of what was being done has been gained. A review of the many developments that have taken place would be of great interest, particularly if interpreted from the standpoint of the chemistry of the materials used. At no time in the past has progress in the use and development of insecticides been so rapid as at present. It is not the purpose of this circular, however, either to review the history of insecticides or to describe developments which are very recent and hence imperfectly understood. Therefore in the following pages, discussion will be limited to the insecticides that are well established and of importance in California.

For convenience in discussing the many kinds of insecticides, it is necessary to classify them according to some scheme. This can be done on the basis of

method of application, and most materials fall into one of these classes: sprays, dusts, and fumigants. This is frequently unsatisfactory, however, for the same material may be used in more than one way. For instance, lead arsenate is both a spray material and a dust, while calcium cyanide is a dusting material and hydrocyanic acid gas is a fumigant, though the active ingredient is the same with both materials.

A more useful classification is according to the *mode of action,* that is, as stomach poisons, contact poisons, and respiratory poisons. This is of particular importance in connection with the feeding habit of any insect under consideration. Those which bite off and chew their food—for example, the codling-moth larva—are usually most easily controlled by stomach poisons, which, on the other hand, are ineffective against insects that get their food by sucking the juices of plants or the blood of animals. The distinction is often not sharp, for typical stomach poisons such as sodium arsenite or sodium fluoride are able to penetrate through the integument of many insects and thus act also as contact poisons.

A third method of classifying insecticides is according to their chemical nature, into such classes as inorganic and organic substances, petroleum derivatives, and plant products. The last two methods correspond rather closely: for most of the stomach poisons are compounds of metals; contact poisons are mainly oils, soaps, and plant products; and fumigants are very largely limited to rather simple organic compounds. Of course, there are notable exceptions to the broad statement just given. The chemical classification is more valuable now than ever before because of the very active endeavors made in the past few years to isolate and identify the toxic ingredient or ingredients of many preparations long used as insecticides. An instance is afforded by pyrethrum, which has been examined chemically and found to be of value only in proportion to its content of two complex organic compounds, pyrethrins I and II. Similarly, all cyanide preparations are effective only as they liberate hydrogen cyanide. Many other illustrations will be given as the various materials are considered.

Grouped according to mode of action, the following materials will be considered:

Stomach poisons: Compounds containing antimony, arsenic, lead, fluorine, copper, or mercury; nonvolatile nicotine compounds; and preparations from derris.

Contact poisons: Nicotine compounds, oils (petroleum and plant), soaps, tar distillates, lime-sulfur, formaldehyde, pyrethrum, derris, and several organic nitro compounds, such as dinitro cresol.

Respiratory poisons: Cyanides, carbon disulfide, carbon tetrachloride, nicotine, paradichlorobenzene, ethylene oxide, ethylene dichloride, naphthalene, sulfur.

Baits, both poisonous and nonpoisonous, form such a distinctive group that they are treated in a separate section (p. 178) in this circular. All other insecticides are grouped according to chemical nature.

Certain other topics of importance, such as compatibility of insecticides and the removal of spray residue, are discussed in the section beginning on page 184.

TYPES OF ANTIDOTES

Since most materials used for pest control are toxic to some extent to humans and animals, it is important to keep them away from children, irresponsible adults, and animals. Unused material should always be kept in the original container with attached label.

If poisoning occurs, call a physician at once, but before his arrival the victim may often be saved by prompt first-aid treatment. If the harmful material is on the skin or in the eyes, wash off with plentiful amounts of water and remove contaminated clothing. If the poisonous material is not known, a useful general antidote is a mixture of the following: 1 tablespoon of magnesia, 1 tablespoon of tannic acid or hydrated iron oxide, 2 tablespoons of finely divided wood charcoal. Stir together in water and give a small amount at intervals. Watch for signs of failure to breathe, and apply artificial respiration if needed.

The emetics, demulcent drinks, stimulants, and sedatives mentioned in connection with the specific antidotes may be prepared as follows:

Emetics.—Mix from 2 to 4 teaspoons of mustard in a cup of warm water and stir to a thick cream, or give from 15 to 30 grains (1 to 2 grams) of powdered ipecac in water; repeat every 10 to 15 minutes.

Demulcent Drinks.—Flaxseed or slippery elm tea, barley water, thin starch, water, milk, white of eggs mixed with water, or thin flour paste; give any of these very freely.

Stimulants.—Put from 10 to 20 drops of aqua ammonia in half a glass of water; or put from ½ to 1 teaspoon of aromatic spirits of ammonia in ½ glass of water; give for one dose and repeat as needed. Strong tea or coffee also are useful.

Sedatives.—Give from 1 to 2 tablespoons of paregoric in ½ glass of water; or give 30 grains (2 grams) of potassium bromide in water for a dose and repeat as required.

ANTIDOTES FOR SPECIFIC POISONS

Alkalis (Sodium or Potassium Hydroxide, Lye, Strong Ammonia).—Wash off with plenty of water, then apply vinegar or lemon juice.

If swallowed, give milk, or orange juice.

Arsenical Compounds.—Give an emetic, such as mustard water, and a mixture of milk of magnesia and iron oxide. After vomiting has occurred, give egg white or other demulcent drinks freely.

Carbon Disulfide, Carbon Tetrachloride, Methyl Bromide.—Get the patient into fresh air at once and give an emetic if the poison has been swallowed. Keep the patient warm and give mild stimulants unless there are convulsions. Delayed effects from methyl bromide are especially dangerous.

Cresol, Cresylic Acid, Carbolic Acid, Phenol.—If external, flood with water, then apply a bland oil, such as olive oil or cottonseed oil.

If swallowed, give milk or other demulcent drink, then an emetic.

Copper Compounds.—Give an emetic and baking soda, milk of lime, or thiosulfate solution. After vomiting has occurred, give demulcent drinks.

Mercuric Chloride (Corrosive Sublimate).—Give egg white and milk in large quantities. Then give water containing baking soda or animal charcoal,

and induce vomiting. Since this poison is extremely dangerous, treatment should be started at once and the patient taken to a hospital as soon as possible.

Cyanides.—Poisoning in the course of insect control usually occurs because hydrogen cyanide gas is inhaled. Get the victim to fresh air, keep him warm, and give artificial respiration if needed. Ammonia or smelling salts are the best stimulants. Since cyanide gas kills very quickly or else the victim almost invariably recovers, first aid must be given very soon or it is of little use.

Fluorides (for example, Sodium Fluoride).—Give limewater, then an emetic, followed by demulcent drinks.

Nicotine.—Give an emetic, then strong tea or coffee. Keep the victim warm.

Tartar Emetic.—Give an emetic, then strong tea, followed by demulcent drinks. Keep the victim warm.

INSECTICIDES CONTAINING ARSENIC

Arsenic Trioxide.—The element arsenic is of use in insect control only in certain of its compounds. Since arsenic has two different combining powers, its compounds fall into two classes which have decidedly different properties. The starting point for the manufacture of the first class, called "trivalent" or "arsenite" compounds, is arsenic trioxide, which is the "white arsenic" of commerce. This substance is only sparingly soluble in water, though sufficiently so to prevent its use on plants. Its uses as an insecticide are therefore limited to poison baits (see under "Baits," p. 179) for control of such insects as grasshoppers, armyworms, and also sowbugs, and to certain other cases where the insecticide is not to be applied to growing plants.

Paris Green.—Another compound of trivalent arsenic is paris green, which was formerly used in very large amounts in the control of many kinds of chewing insects and is still used on particularly hardy plants. Its content of water-soluble arsenic, however, is high and variable (1 to 5 per cent or even higher). The decreasing use of paris green is an example of the previously mentioned tendency to use materials of known and strictly controlled properties. It may be substituted for arsenic trioxide or sodium arsenite in poison baits if used at about double the proportions given for the other compounds.

Lead Arsenates.—The second class of arsenical compounds, the pentavalent or arsenate type, includes some of the most important of all insecticides. Two compounds containing lead are extensively used in controlling all kinds of chewing insects. Each has been called by various names: (1) *standard lead arsenate,* also called acid lead arsenate, lead hydrogen arsenate, di-lead arsenate; and (2) *basic lead arsenate,* also called triplumbic lead arsenate, neutral lead arsenate. These two substances differ in the ratios of arsenic to lead. The standard lead arsenate averages approximately 20 per cent arsenic and 60 per cent lead by weight, whereas the basic averages approximately 14 per cent arsenic and 63 per cent lead.

The standard type of lead arsenate contains more arsenic per pound than the basic type, is a stronger poison, and acts more quickly. It is also more susceptible to the action of other chemicals, particularly those of an alkaline

nature (such as soaps and lime-sulfur solutions), and is more or less dissolved by them when used in a combination spray. The soluble arsenic so formed may lead to severe burning of tender foliage. In moist climates along the coast, or in continuously damp and cloudy weather elsewhere, considerable arsenic is apt to be rendered soluble and to cause serious foliage injury even when standard lead arsenate is used by itself. Differences in various brands according to whether they are "deflocculated" or not will be discussed under the topic "Emulsification and Deposit of Spray Materials" (p. 183). The concentration needed in sprays varies with the insect and many other conditions.

A ruling of the California State Department of Agriculture dated January, 1942, prohibits the sale of lead arsenate for use on vegetables and berries.

FORMULA 1

STANDARD LEAD ARSENATE

Standard lead arsenate powder	2 to 4 pounds
Water	100 gallons

To secure adequate wetting of foliage and fruit, a spreader should be used at the amount recommended by the manufacturer. For the control of codling moth on apples or pears, however, the first (calyx) spray is often used without a spreader, since the purpose of this spray is primarily to fill the small calyx cups with lead arsenate rather than to form an even film over the surface of fruit or leaves. A spreader is incorporated in certain brands of lead arsenate during preparation, and hence more is usually not needed. In all such cases the manufacturer's recommendations should be followed carefully. For a discussion of the function of spreaders, see page 183.

Basic lead arsenate is a weaker poison and acts more slowly than the acid form. It is much more stable, not being appreciably decomposed during damp weather or by other insecticides of a slightly acidic or alkaline nature. It may be used safely on stone fruits, beans, nuts, and other susceptible plants. The proper concentration is subject to various conditions.

FORMULA 2

BASIC LEAD ARSENATE

Basic lead arsenate powder	2½ to 5 pounds
Water	100 gallons

As with standard lead arsenate, a spreader should also be used.

Both standard and basic lead arsenates are also sold as pastes, which contain approximately half as much arsenic as the corresponding powders and hence should be used at twice the dosage.

Either kind of lead arsenate is often used in combination with fungicides or other insecticides for control of more than one pest. A useful formula for control of codling moth and scab on pears is as follows:

FORMULA 3

LEAD ARSENATE AND BORDEAUX MIXTURE

Standard lead arsenate	3 pounds
Copper sulfate (bluestone)	10 pounds
Quicklime	10 pounds
Water	100 gallons

Combine the copper sulfate and quicklime as described under "Bordeaux Mixture" (p. 158) and then add the lead arsenate, preferably made into a thin paste with a little water.

For a discussion of compatible and noncompatible mixtures, see page 184.

For a discussion of lead arsenate remaining on fruits or vegetables at harvest see section on "Spray Residue" (p. 188).

Calcium Arsenate.—A compound somewhat similar to the lead arsenates is calcium arsenate. The pure material, however, gives rise to far too much soluble arsenic, and accordingly all commercial products contain varying amounts of hydrated lime, usually from 20 to 30 per cent. The chief uses of calcium arsenate are as dusts and in poison baits. An example of such a dust is that containing equal parts of commercial calcium arsenate and dusting sulfur, which is recommended for control of the alfalfa weevil.

CARBON DISULFIDE

Carbon disulfide is a liquid which evaporates quickly when exposed to the air, forming a heavy and inflammable vapor of great penetrating power. In using the material for the control of insects infesting stored products—for example, granary weevils—it must be placed near the top of the chamber in a shallow container in order that the heavy vapors as they are given off may thoroughly diffuse through the air contained in the space to be fumigated. The proper amount to use depends upon the type of room being fumigated and ranges from 10 pounds to about 30 pounds per 1,000 cubic feet in ordinary rooms where the walls and floor have not been made especially tight. The best results are obtained by doing this work when the temperature is above 70° F. Since the vapors of carbon disulfide are very inflammable, precaution must be taken to keep all flames and sparks away.

Carbon Disulfide Emulsion.—This is a rather unstable emulsion which is procurable from manufacturers as needed and is a valuable soil fumigant for the control of certain pests. In the San Francisco Bay region, it has proved effective in killing the garden centipede in the soil.[44] Good results have been obtained by diluting the emulsion 1 part to 300 parts of water and applying it to the surface of the soil at the rate of 5 gallons per square yard. See "Soil Disinfection" (p. 187).

CARBON TETRACHLORIDE

This may be substituted for carbon disulfide in household fumigation by using it in the same manner and slightly increasing the amount used. It is noninflammable and consequently safer than carbon disulfide, and its lower toxicity makes it safer for the operator.

CHLOROPICRIN

Chloropicrin, which is a tear gas used in warfare, has proved to be useful for the control of insects infesting stored products and of certain soil pests. Chloropicrin is a very heavy gas and penetrates well. It is relatively free from fire hazard and is easily detected at noninjurious concentrations by its power-

[44] See: Michelbacher, A. E. Chemical control of the garden centipede, *Scutigerella immaculata*. California Agr. Exp. Sta. Bul. 548:1–19. 1932.

ful effect on the eyes. For best results the manufacturers' directions should be followed.

COAL-TAR DISTILLATES

The destructive distillation of coal gives rise to a great variety of products, of which one fraction is known as "coal-tar oil." From this several proprietary "tar-distillate washes" or "fruit tree carbolineums" are obtained. These differ considerably in composition, but all contain carbolic acid, naphthalene, and other complex organic compounds. Many of these are toxic to plants; so use of the coal-tar preparations is at present limited to the dormant season. They are particularly effective against overwintering eggs.

COPPER COMPOUNDS

Compounds of copper are primarily fungicides but they are also of considerable use as repellents against certain insects, such as flea beetles and leaf beetles on melons, potatoes, tomatoes, and tobacco. The very frequent use of bordeaux mixture in conjunction with many insecticides makes its consideration important here.

Bordeaux Mixture.—As the name indicates, this is not a single substance, and over fifty years' use has not entirely cleared up the uncertainty as to what compounds are present under all circumstances. The ingredients entering into it are copper sulfate (bluestone), quicklime (or hydrated lime), and water. The objective in preparing any bordeaux mixture is to obtain a very finely divided product that remains in suspension and adheres well. (Emulsifying agents are not usually added, though they often may be beneficial.) The composition is usually expressed in terms of the ratios of bluestone, quicklime, and water, in that order. Thus 8 pounds of bluestone, 10 pounds of quicklime, and 100 gallons of water is known as 8–10–100 mixture. Any other composition may be described similarly, and, of course any desired volume of water may be used if the ratios of ingredients are kept the same.

A satisfactory bordeaux mixture may be made as follows: Slake the lime and dissolve the bluestone in separate barrels. Fill the spray tank half full of water, add the dissolved bluestone, strain in the slaked lime while the agitator is running, add remainder of water, and mix thoroughly. In order to hasten solution of the bluestone, it should be ground as fine as possible and placed in a sack kept near the top of the water in the barrel. Another satisfactory method is to dissolve the bluestone in a small volume of hot water and then dilute with cold water. It must be kept from contact with all common metals except copper, for otherwise copper will be thrown out of the compound. Whatever system of preparation is used, it is desirable to have both the bluestone and the lime as much diluted as is convenient before mixing, and the solutions should be cold before they are mixed.

FORMULA 4
10–10–100 BORDEAUX MIXTURE

Bluestone	10 pounds
Quicklime	10 pounds
Water	100 gallons

Hydrated lime may be used, but it should be finely ground and preferably

should be left to soak in the water for several hours before using. Use one third more than of quicklime in any particular formula.

A bordeaux paste useful for repelling tree-boring insects may be made by the above formula if only sufficient water is used to bring the mixture to the desired consistency.

Commercial Copper Preparations.—Prepared bordeaux mixtures are on the market in the forms of pastes or dry powder. They do not remain in suspension in water so well as freshly made bordeaux mixture, but they are more convenient, especially for the user who needs only a small amount.

Numerous other commercial copper preparations are available, usually under trade names. Chemically these are cuprous oxide, basic copper sulfate, copper silicate, copper resinate, and other compounds. While some of these are safer for copper-sensitive plants than bordeaux mixture, most of them are adapted to specific uses, and the manufacturer's recommendations must be followed carefully.

Copper Carbonate.—For dusting seed wheat for bunt, use 2 ounces of copper carbonate dust to a bushel. The dust should be intimately mixed to cover each seed thoroughly. The copper carbonate dust should contain 50 per cent of copper in the form of carbonate and hydrate of copper, and should be sufficiently fine to weigh approximately 32 pounds to a cubic foot. The dusted seed may be stored without injury from the dust. Grain so treated is absolutely free from the attacks of the granary and rice weevils and other insects which attack stored grains.

CYANIDE COMPOUNDS

Hydrogen Cyanide.—The simplest cyanide compound is hydrogen cyanide (HCN), often called "hydrocyanic acid gas." This is the most effective fumigant in common use but is so poisonous that only skilled operators should attempt to use it. The material is supplied in steel cylinders under sufficient pressure to liquefy it. Upon releasing the pressure, gas is liberated. This has largely replaced the pot method, in which sodium cyanide was treated with sulfuric acid to liberate hydrogen cyanide. For a discussion of the use of liquid hydrogen cyanide to control scale insects on citrus, see Extension Circular 123.[45]

Calcium Cyanide.—This material, in the form of granules or dust, is an increasingly important insecticide. It differs from other cyanide compounds in that an acid does not need to be added in order to liberate hydrogen cyanide. Moisture from the air is sufficient unless the humidity is low. The granules or dust is used to eradicate household pests, grain insects, and the like, an average dosage for greenhouses being ½ to 1 ounce per 1,000 cubic feet with overnight exposure. For grain insects, 25 pounds per 1,000 bushels is effective.

The dust may be used straight or diluted with 50 to 75 per cent of hydrated lime, sulfur, or other carrier. It is used chiefly to control aphids, leafhoppers, bugs, and similar insects. Either the flakes or dusts are used as soil fumigants. Its use must be avoided with plants when they are moist because of danger of burning.

[45] Quayle, H. J. Control of citrus insects and mites. California Agr. Ext. Cir. 123:1–31. 1941. Fumigation of citrus trees is subject to county regulations in the areas concerned.

DINITROPHENOLS, DINITROCRESOLS, AND DERIVATIVES

During recent years a number of commercial products containing nitro derivatives of phenol or cresol have come on the market. These are soluble to only a very slight extent in water and to the extent of several per cent in spray oils. If they are treated with alkali to form the sodium or ammonium derivatives, the solubility ratio in water and oil is reversed, for these derivatives are freely soluble in water and only slightly soluble in oil. By keeping the spray water acidic, it is possible to keep the dinitro compounds in the oil, and they are of value as oil-soluble toxicants for red spider and similar pests.

The ordinary dinitrophenol and dinitrocresol are highly injurious to foliage and hence are chiefly of value in plant protection during the dormant season

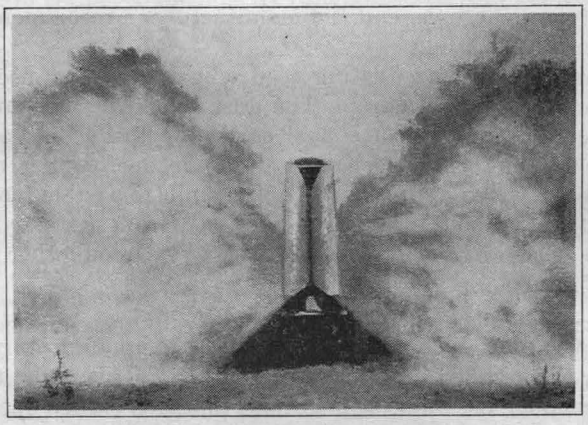


Fig. 181.—Dusting citrus trees with a modern power machine.

or as weed killers. For such use the water-soluble sodium derivatives, such as sodium dinitro-*o*-cresolate, are prepared either as dry powders or as solutions of fixed concentration in water. In the latter case a special wetting agent usually is included in the solution.

A compound somewhat similar, which is much safer on foliage, is dinitro-*o*-cyclohexylphenol, sometimes called "DNOCHP" for short. This substance is slightly soluble in water, but dissolves to several per cent in spray oils. It may be made water-soluble by addition of alkali, such as sodium hydroxide, but at the same time the solubility in oil is greatly decreased. Solutions in oil are also used, for example, a 4 per cent solution of DNOCHP in winter oil. In the presence of lime, the calcium salt is formed and the effectiveness is greatly decreased. Similarly, lime-sulfur is not compatible.

Dusts containing dinitro-*o*-cyclohexylphenol or derivatives formed from it are often called "DN dusts" or "dinitro dusts." A derivative of particular value for use on citrus is dicyclohexylamine dinitro-*o*-cyclohexylphenate. A new type of duster used for applying this and other dusts to citrus trees is shown in figure 181. The best diluents are acidic, principally walnut-shell flour or redwood-bark flour.

Since new compounds of this family and new combinations are under experiment, it is probable that improved formulas will be found. Hence the manufacturers' recommendations should be sought.

ETHYLENE OXIDE, ETHYLENE DICHLORIDE

Ethylene oxide, ethylene dichloride, and similar materials are commercially available. Particularly when mixed with carbon dioxide, they combine safety with high efficiency as fumigants against household and grain pests. Various commercial products are sold in steel cylinders ready for use.

FLUORINE COMPOUNDS

Fluorine is a constituent of hydrofluoric acid, which is used to etch glass. Several derivatives of this compound have been advocated as insecticides. The simplest, sodium fluoride, is too soluble for use on plants but may be used in poison baits; for example, it may be substituted in formulas 27 and 28. Another material which is finding use is cryolite, which is a complex fluoride containing both sodium and aluminum, often called "sodium fluoaluminate." This compound is but slightly soluble and can be used against many chewing insects. In damp climates it is apt to cause burning. Both the naturally occurring mineral and a synthetic preparation are on the market.

A formula used for late-summer spray against the codling moth on deciduous fruit is:

FORMULA 5

CRYOLITE SPRAY

Cryolite (sodium fluoaluminate)	3 pounds
Blood-albumin spreader	4 ounces
Water	100 gallons

One to 2 quarts of summer oil emulsion may be substituted for the blood-albumin spreader.

Cryolite as a dust according to the following formula is used to control the orange tortrix and many other insects.

FORMULA 6

CRYOLITE DUST

Cryolite (sodium fluoaluminate)	50 per cent
Frianite or talc	50 per cent

If citrus thrips also must be controlled, dusting sulfur may be substituted for the frianite and the proportion varied to 60 per cent sulfur. Orange tortrix, citrus thrips, and red mite may all be controlled by a mixture of 40 per cent cryolite and 60 per cent commercial sulfur and dinitrophenol dust.

The addition of a little oil increases the retention of the dust and thereby prolongs its action. A useful formula is:

FORMULA 7

CRYOLITE DUST PLUS OIL

Cryolite	35 per cent
Frianite, talc, or walnut-shell flour	63 per cent
Petroleum oil	2 per cent

Fluosilicates.—Compounds containing silicon as well as fluorine have been extensively studied as insecticides. The two best known of these are sodium fluosilicate and barium fluosilicate. These materials are used chiefly as dusts and are sold mixed with varying amounts of inert fillers, under several trade names.

In moist climates, there is danger of burning foliage, especially with the sodium compound. The manufacturer's recommendations as to dosage should be followed carefully.

Concerning the regulation regarding fluorine compounds on fruit and vegetables at harvest see section on "Spray Residue" (p. 188).

MERCURY COMPOUNDS

All soluble compounds of mercury are extremely poisonous and are widely used as germicides. Mercuric chloride (corrosive sublimate) is used to some extent in treatment of plant diseases. Its insecticidal use is largely confined to action as a larvicide and repellent for root maggots and similar insects.

FORMULA 8
MERCURIC CHLORIDE SOLUTION

Mercuric chloride	1 ounce
Water	8 gallons

This gives a 1:1,000 solution. Tablets to make this strength when added to 1 pint of water may be obtained at drugstores. Distilled or rain water should be used, and the solution must not be kept in a metal container. Contact with any kind of organic matter or absorbent material, for example, clay, results in removal of the mercuric chloride from solution. The solution may be prepared more readily with warm water.

It must be stressed that this substance is extremely poisonous even in very dilute solution. If it is accidentally swallowed, give whites of several eggs at once. Then the stomach should be emptied as completely as possible, and eggs, starch, or flour paste swallowed liberally, until a physician can be called.

The slightly soluble compound, mercurous chloride, or calomel, is useful against certain root-infesting insects, for example, the cabbage maggot. Mercurous chloride is used as a dilute dust, for example, 1 part to 25 parts of talc.

METHYL BROMIDE

Increasing use is being made of methyl bromide for control of pests attacking stored products. It is a gas at ordinary temperatures, but since the boiling point is 40.3° F, it is easily liquefied and can be handled in light metal cylinders. The vapor is about three and a half times as heavy as air; so care must be taken that the fumigant reaches the upper part of storerooms, grain elevators, or other storage spaces.

Methyl bromide is poisonous to man and animals, and masks should be worn during its use, since the odor is scarcely noticeable at toxic concentrations. It has the important advantage of being nonexplosive.

NAPHTHALENE

Naphthalene is sold either as flakes or as the well-known moth balls. Its toxicity to insects is comparatively low, but it has a use in protecting certain stored products and in the field. A formula recommended for repelling the western flat-headed borer and other insects is:

FORMULA 9

SOAP AND NAPHTHALENE REPELLENT

Fish- or whale-oil soap	25 pounds
Water	1½ gallons
Flaked naphthalene	12½ pounds
Flour	2 pounds

Dissolve the soap in hot water and stir in the flour. Add flaked naphthalene and heat to 180° F until thoroughly dissolved. Cool and store in sealed containers. For use, thin to consistency of paint and apply to trunks and limbs with brush.

OILS

Nature of Petroleum Oils.—Petroleum is a complex mixture of substances consisting mainly of carbon and hydrogen but with a varying amount of sulfur and nitrogen-containing compounds also present. By distillation, usually under a vacuum, it is divided into a number of fractions. That fraction which at normal pressure distills between approximately 500° and 750° F is the source of spray oils. It may also be considered as light lubricating oil, for the fraction coming over at the next higher temperature range gives the commercial lubricating oils. Since material distilling over such a wide range would vary greatly in its properties, it is customary to take the spray-oil fraction in two or more cuts, each covering a narrower temperature interval. These cuts are still composed of a great variety of compounds, some of which are very toxic to plants. It is therefore necessary to purify or refine them. This is done by mixing either with cold liquid sulfur dioxide or with hot sulfuric acid. Both processes are often used to obtain very highly refined oils. In order to determine how far the process of refinement has been carried, a test has been devised called the "unsulfonated residue test." This depends upon the fact that when a petroleum oil is treated with strong hot sulfuric acid under certain specified conditions, a reaction goes on until only very nonreactive constituents of the oil are left. For any particular sample of oil, the portion not acted upon will be a certain percentage of the volume taken for the test. This percentage, called the "unsulfonated residue," represents the portion which is too inert chemically to react with sulfuric acid under the conditions of the test. It has been found that toxicity to plants is less the greater the unsulfonated residue (U. R.), but effectiveness as an insecticide is only slightly decreased.

The various fractions obtained by this combination of distillation and treatment with sulfuric acid are washed with alkali to remove excess acid and

blown with warm air to remove moisture. They then are the spray oils of commerce. A number of other tests are used to further identify their properties. The most important is the distillation range. The oil is heated in a long-necked flask under certain definite conditions, and the percentage distilling over at 5- to 25-degree intervals of temperature is determined. The California State Department of Agriculture has established a classification of oils used on foliage according to the percentage by volume distilling at 636° F under atmospheric pressure. Five classes are recognized, as follows:

Class	Per cent by volume distilling at 636° F
Light	64 to 79
Light medium	52 to 61
Medium	40 to 49
Heavy medium	28 to 37
Heavy	10 to 25

Another property used in describing spray oils is the viscosity, which is a measure of the ease of flowing. It is stated in terms of the number of seconds needed for 60 cubic centimeters of an oil to flow through the orifice of a Universal Saybolt viscosimeter when the latter is kept at 100° F. The more viscous the oil the longer the time required to flow out of the viscosimeter, and vice versa. The viscosities of spray oils vary from about 40 seconds to considerably over 100.

Selection of Oils.—A very important consideration in the use of oils is the fact that plants and trees are much more easily injured when they are growing and in foliage than when they are in dormant condition. This has given rise to the grouping of spray oils into two classes: (1) dormant or winter oils, whose unsulfonated residue is approximately 65 to 80 per cent; and (2) foliage or summer oils, whose unsulfonated residue is approximately 80 to 100 per cent. The viscosities vary widely, with the dormant oils more viscous on the average than the summer oils. In general, the distillation ranges and viscosities vary similarly. Since both the insecticidal value of oils and their harmful action to plants are also proportional to the length of time they remain after spraying, the distillation range affords a useful basis for classifying both summer and winter oils. An important distinction between the requirements for spraying deciduous trees and those for spraying citrus trees is that the latter have no true dormant season and accordingly can only be treated with summer oils. The two groups of oils overlap somewhat, for oils of intermediate properties are often necessary for use on deciduous trees at the time of budding. Further specifications will be given in the sections on tank-mix oils for citrus and for deciduous fruit trees.

Oil is used in four different ways: as straight oils, commercial emulsions, emulsive oils, and tank mix.

Straight Oils.—The most direct method of applying oil consists in either using a small high-pressure pump to force the oil through a paint-gun-type nozzle or using an air blower with an auxiliary pump which sends the oil at low pressure into the fast-moving stream of air. In either case the oil is broken up into very small droplets so that it resembles a fog. The term "vapor spray-

ing" is often used to describe this process. A formula found to be efficient against the grape leafhopper[46] is:

FORMULA 10

OIL AND PYRETHRUM VAPOR SPRAY

Oil (unsulfonated residue 90, viscosity 60 sec.)	10 gallons
Refined kerosene	87½ gallons
Extract of pyrethrum (containing 2 grams of pyrethrins per 100 cc)[47]	2½ gallons

Use at the rate of 2 to 5 gallons per acre.

Commercial products containing the same concentration of pyrethrins (0.05 per cent) as the above spray and intended for the same use are available for those who do not wish to mix their own spray.

Commercial Oil Emulsions.—Stable emulsions containing approximately 85 per cent oil are made by a large number of manufacturers. A wide variety of oils is used but, in general, these preparations fall into the two classes of winter and summer oils previously mentioned. The convenience of using emulsions, particularly for the small user, has made them very popular, and supervision by the State Department of Agriculture has standardized the oils used. Data on the oils used are published by the State Department of Agriculture, but the emulsifying agents are secret. Since the type and amount of emulsifying agent largely control the amount of oil that is deposited in spraying, it is not possible to obtain the same results when various oil emulsions are used at the same concentration, even though the oils in them are similar. Each manufacturer gives directions for using his preparations. One decided advantage that commercial oil emulsions have is that they require comparatively little agitation, since an excess of emulsifying agent is used. The corresponding disadvantage is that some deposit less oil than tank-mix sprays of equal oil content, and somewhat higher concentrations may be advisable for securing equal control of the same insects. The emulsions are made in two forms known as the paste and flowable types. The latter has become more popular because it is easier to remove from the container and to disperse in the spray tank.

Emulsive Oils.—A distinct advance over the commercial oil emulsions was the introduction of emulsive oils. These are more or less clear solutions of an oil-soluble emulsifier dissolved in the spray oil. Since only a small amount of emulsifier is required, these products consist of from 97 to 99 per cent oil and hence can be used at lower concentrations than the emulsions. Also, since there is no necessity for maintaining an emulsion in the barrel or other container in which they are sold, only enough emulsifier is used to ensure proper dispersion in the spray tank. This results in heavier deposit upon application to the plants. Complications occasionally arise when the spray water is unusually hard, and various water conditioners may be recommended by the manufacturers.

[46] See: Lamiman, J. F. Control of the grape leafhopper in California. California Agr. Ext. Cir. 72:1–20. Reprinted 1937.

[47] See section on "Pyrethrum" (p. 172) for the meaning of this phrase.

While the manufacturers differ somewhat in dosage recommendations for their products, the following are typical:

DOSAGE OF OIL EMULSIONS AND EMULSIVE OILS FOR USE IN DORMANT SEASON

Insect or mite	Gallons of oil emulsion per 100 gallons of spray	Gallons of emulsive oil per 100 gallons of spray
San Jose scale	5	4
Brown apricot scale	4	3
Italian pear scale	7	5
Leaf-roller eggs	7	5
Almond mite eggs	3	2½

DOSAGE OF OIL EMULSIONS AND EMULSIVE OILS FOR USE IN FOLIAGE SEASON

Insect or mite	Gallons of oil emulsion per 100 gallons of spray	Gallons of emulsive oil per 100 gallons of spray	
Red spider	1½ to 2	1½	
Aphids and immature thrips	1½ to 2	1½	With ¾ pint 40 per cent nicotine sulfate (for example, Black Leaf 40)
Leafhopper nymphs	2	1½	
Codling moth	1	1	

Tank-Mix Oils.—Before the introduction of emulsive oils, the Agricultural Experiment Station of the University of California pioneered in the development of the tank-mix method of preparing oil sprays. By this method the oil and emulsifying agent are added separately to the spray water and the emulsion is prepared in the spray tank immediately before use. Accordingly, the amount of emulsifier can be varied to suit local conditions, and the best possible use of the spray oil may thus be made. Since the cost of oil and emulsifier is considerably less than that of either commercial emulsions or emulsive oils, a large saving is possible. On the other hand, each step of the process must be thoroughly understood and carried out correctly or the results will be unsatisfactory either because of poor control or because of plant injury.

Tank-Mix Oil Spray for Citrus.[48]—The five grades of oil mentioned on page 164 are available from several companies for the preparation of tank-mix oil sprays. The most commonly used emulsifier is powdered-blood-albumin spreader, which consists of 1 part commercial blood albumin plus 3 parts fuller's earth. It is used ordinarily at the rate of 4 ounces to 100 gallons of spray. The order of adding materials to the spray tank is not important, but it is preferable to add both the oil and the emulsifier while the spray tank is being filled so that the emulsion is first formed in only a part of the spray water. Agitation must be continued constantly until the tank is emptied. Most spray outfits in the citrus districts are adequately powered to run large agitator blades of the propeller type at about 200 r.p.m.

For use on citrus trees the concentration is usually 1⅔ per cent. For oranges the light-medium or medium grades are preferable. Lemons tolerate the same dosage of medium and of medium-heavy oils. Since local conditions in citrus-growing regions have very great effects upon pest-control programs, advice should be sought from local authorities, particularly as to time of spraying and use of combined sprays.

[48] For more information regarding citrus pest control see:
Quayle, H. J. Control of citrus insects and mites. California Agr. Ext. Cir. 123:1–31. 1941.
Smith, Ralph H. The tank-mixture method of using oil spray. California Agr. Exp. Sta. Bul. 527:1–84. Reprinted 1933.

Tank-Mix Spray for Deciduous Fruits.[49]—For use during the foliage season, light or light-medium oils of 90 per cent or higher unsulfonated residue are satisfactory. On Yellow Newtown or Smith Cider apples, only light oil should be used.

During the dormant season, tank-mix sprays are very useful for destruction of various scale insects, brown-mite eggs, and leaf-roller eggs. Oils of 70 per cent or slightly higher unsulfonated residue and 100 to 120 seconds Saybolt viscosity at 100° F are most widely used. Particular attention should be paid to securing adequate agitation with such comparatively unrefined oils. If available power is low, it is advisable to use flat paddles approximately 13 inches long and 2 inches wide through the shank, with flat tips 3 inches by 4 inches set crosswise to the shank. Four such agitators running at 100 r.p.m. provide adequate mixing in a 200-gallon tank and with 3-inch by 8-inch tips are satisfactory in a 300-gallon tank. The same blood-albumin spreader that is used for citrus spraying is entirely satisfactory for dormant sprays.

Combinations of Oil with Other Insecticides.—Oils enter into the formulas for many combination sprays. In general, tank-mix oils, emulsive oils, and commercial emulsions may be used interchangeably in these sprays. The following formulas indicate some of the useful combinations:

FORMULA 11

OIL AND LIME-SULFUR

Commercial oil emulsion (100 to 120 seconds viscosity and 70 per cent unsulfonated residue)	4 gallons
(Or emulsive oil or tank-mix oil of like specifications; 4 ounces blood-albumin spreader with tank-mix oil)	3 gallons
Commercial lime-sulfur solution[50]	3 gallons
Water to make	100 gallons

This mixture is particularly useful for winter control of mealybugs on deciduous trees and vines.

FORMULA 12

OIL AND NICOTINE (DORMANT USE)

Commercial oil emulsion (100 to 120 seconds viscosity and at least 70 per cent unsulfonated residue) or emulsive oil or tank-mix oil of like specifications (4 ounces blood-albumin spreader with tank-mix oil)	1½ gallons
Nicotine sulfate 40 per cent (for example, Black Leaf 40)	¾ pint
Water to make	100 gallons

This is used for the control of adult pear thrips, aphids, and scales on trees in bud or before the leaves appear.

The addition of ½ pint of ammonia solution (20 to 24 per cent NH_3) releases the nicotine more rapidly and is particularly useful in cool weather.

[49] For further information see:

Borden, Arthur B. Oil sprays for deciduous fruit trees by the tank-mixture method. California Agr. Exp. Sta. Cir. 345:1–15. 1938.

[50] If homemade lime-sulfur solution is used, the amount necessary may be calculated from the Baumé reading by use of table 1, p. 175.

A similar formula for summer use is:

FORMULA 13
OIL AND NICOTINE (SUMMER USE)

Commercial oil emulsion (60–70 seconds viscosity and 90 per cent or above unsulfonated residue) or emulsive oil or tank-mix oil of like specifications (4 ounces of blood-albumin spreader with tank-mix oil)	1½ gallons
Nicotine sulfate 40 per cent (for example, Black Leaf 40)	¾ pint
Water to make	100 gallons

A fungicide is included in the following formula, which is useful in early spring for the control of hatching aphids and thrips and brown rot.

FORMULA 14
OIL, NICOTINE, AND LIME-SULFUR

Commercial oil emulsion (100–120 seconds viscosity and at least 70 per cent unsulfonated residue) or emulsive oil or tank-mix of like specifications (4 ounces blood-albumin spreader with tank-mix oil)	1½ gallons
Nicotine sulfate 40 per cent (for example, Black Leaf 40)	¾ pint
Lime-sulfur solution	5 gallons
Water to make	100 gallons

Bordeaux mixture 10–10–100 may be substituted for the lime-sulfur by using 10 pounds of quicklime and 10 pounds of copper sulfate in the above formula.

A general winter cleanup spray for moss which also controls San Jose scale is the following combination:

FORMULA 15
OIL AND CAUSTIC SODA

Commercial oil emulsion (100–120 seconds viscosity and 70 per cent unsulfonated residue)	5 gallons
(Or emulsive oil or tank-mix oil of like specifications; 4 ounces of blood-albumin spreader with tank-mix oil)	4 gallons
Caustic soda[51] (lye)	1 to 3 pounds
Water to make	100 gallons

Oils as Carriers and Stickers.—Oils are useful as carriers and stickers for toxic substances, which they hold either in solution or suspension. A well-known example is the use of refined kerosene as a carrier for pyrethrins in fly sprays, in which case the oil has only negligible effect. Field sprays have been developed recently in which the oil is used for its own toxic effects but the amount needed may be greatly reduced by incorporation of an oil-soluble toxicant. An example is the solutions of rotenone in oil for control of various scales on citrus.

Oil emulsions have long been used with lead arsenate, bordeaux mixture, and other materials to increase the adhesiveness of the solid material. A step beyond this practice is the treatment of the solid—for example, lead arsenate with straight oil—in order to make the surface water-repellent and thus increase deposit. Such "inverted" mixtures are often difficult to apply because of the tendency of the suspension to clump in the spray tank, but numerous commercial "deposit builders" have been designed which avoid this difficulty.

[51] The smaller amount of caustic soda is satisfactory in the interior valleys and the larger amount is only required where moss growth is very vigorous, as in the coastal regions.

PARADICHLOROBENZENE, OR PDB

Paradichlorobenzene is a white crystalline substance which is insoluble in water and evaporates slowly at a temperature of 55° to 75° F and more rapidly at higher temperatures. The vapor is more than five times heavier than air and more than twice as heavy as carbon disulfide vapor. Fortunately the vapor is noncombustible and practically nonpoisonous to man and animals for reasonable exposures. An important use is for control of soil-infesting insects.

Paradichlorobenzene is such a long name that it is often convenient to abbreviate to "PDB." Various trade names, such as "Paracide" and "Crystal Glass," also are used.

In applying the material, important considerations are soil moisture and temperature. Because gases do not readily circulate in a thoroughly wet soil, applying paradichlorobenzene is useless unless the soil is not more than ordinarily moist; in California the soil is usually in proper condition during the summer and fall except just after irrigations. In such cases a week or two after the application of water would be preferable. For best results the soil temperature should range from 75° to 85° F, for under such conditions the paradichlorobenzene volatilizes more rapidly and the insects are more active, require a greater air supply, and are consequently more readily killed by the vapor.

In California the period from the first of May until November may be roughly designated as the proper time to make the applications, provided the soil temperature is over 55° F and the soil moisture is not excessive.

From ¾ to 1 ounce of paradichlorobenzene is sufficient to treat an average-sized tree. First, level the surface of the soil around the base of the tree; then sprinkle the material around the tree in a continuous band or circle 2 inches wide with the inner margin 2 to 4 inches from the bark of the tree. Cover the material with soil around the base of the tree to a depth of 2 to 4 inches and pack well with several strokes of the shovel.

Growers should take all precautionary measures possible and at least observe the following:

1. Avoid using excessive dosages.

2. Do not place the crystals in contact with the bark of the trunks, stems, or the roots of the plants.

3. Do not apply the material immediately before or after irrigation; and do not wet the surface of the soil until 2 or 3 weeks after applications of the crystals, or until the crystals have volatilized.

4. In treating nursery stock and young trees, remove the residue after 3 weeks.

5. Do not apply paradichlorobenzene during the winter and early spring. Late summer and fall are the best times for such applications.

6. Only one application a year is advisable. Several treatments in one season may be fatal to the plants.

7. Paradichlorobenzene is recommended in the orchard and garden only for insects which attack the plants at or below the surface of the soil. It is of no value for borers which infest the trunks and limbs aboveground. Although

it is being recommended by some insecticide dealers for all wood-boring insects, particularly for the western flat-headed borer, this insect and the other wood borers which work aboveground cannot be satisfactorily reached by the fumes of the fumigant and *cannot be controlled by it!*

PLANT PRODUCTS

A significant feature of recent investigations of insecticides has been the chemical studies on many plant products. These have sought to discover and study the toxic factor or factors included in the earlier insecticidal preparations from plants, in order that materials of high purity and known composition may be made available.

Rotenone.—The roots of several species of tropical plants have long been used by natives as fish poisons. Investigation of these has shown that many of these plants contain compounds of high insecticidal potency. The most toxic of the compounds is rotenone, and analysis is usually expressed in terms of rotenone and total extractives, which include the other valuable compounds.

The plants concerned are varied in appearance and habit of growth, and their popular names differ in various regions. In the Orient several species of *Derris* are the principal source, and in South and Central America numerous species of *Lonchocarpus* are most important. These are popularly called cube, timbo, or barbasco.

The three forms of rotenone-containing materials are: ground roots intended for use as dusts or sprays, extracts of the toxic constituents either ready for use or intended for suitable dilution in sprays, and dusts consisting of impregnated inert carriers such as talc to which extracts have been added. Since various commercial products contain differing concentrations of active ingredients, the manufacturer's specifications and recommendations should be followed. Alkaline diluents should be avoided because rotenone is less stable in the presence of any alkaline material.

Different species of insects and cold-blooded animals, such as fish, differ greatly in their susceptibility to rotenone. Warm-blooded animals and humans are in general but little affected when the material is swallowed or applied to the skin, and this safety is a very valuable property. Certain individuals, however, are hypersensitive and develop severe skin irritation.

Nicotine.—Tobacco dusts and infusions were used many years ago both as fumigants and as contact poisons. Substantial progress, however, was not made until the toxic constituent, nicotine, was isolated in commercial quantities. Certain facts must be kept in mind in order to use nicotine preparations to the best advantage. By itself, nicotine is a fairly volatile and very toxic liquid. It reacts with a great variety of substances to form nonvolatile compounds, which are also relatively nontoxic as long as they remain undecomposed. Free nicotine is liberated from any of its compounds by the addition of an alkaline substance such as lye, soap, washing soda, lime, bordeaux mixture, lime-sulfur, and to a less extent even by limestone. For insecticidal use it is marketed chiefly as a 40 per cent solution of nicotine in the form of its compound with sulfuric acid, that is, as nicotine sulfate. Unless otherwise stated, the directions and formulas of this circular are given in terms of actual nicotine.

Nicotine Sprays.—These are very widely used against soft-bodied insects such as aphids. An alkaline substance, sometimes called an activator, is added. A common formula is:

FORMULA 16
NICOTINE AND SOAP

Nicotine sulfate solution, 40 per cent (for example, Black Leaf 40)	1 pint
Liquid fish-oil soap	1 to 1½ gallons
Water	100 to 150 gallons

For small quantities use 1 teaspoon of nicotine solution and 2 tablespoons of soap to 1 gallon of water. This formula contains a large excess of soap, which also has insecticidal value.

For plants sensitive to soap, such as potatoes and tomatoes, formula 16 may be altered to 1 to 1½ pounds of soap or ¼ pint of ammonia solution (20 to 24 per cent NH_3).

The formula recommended for use against the first-brood nymphal stage of the grape leafhopper (see p. 76) is:

FORMULA 17
NICOTINE AND CASEIN

Nicotine sulfate solution, 40 per cent (for example, Black Leaf 40)	1 pint
Calcium caseinate spreader	½ pound
Water	100 gallons

Nicotine has received much attention of late as a substitute for lead arsenate in the late sprays for control of the codling moth. Here it functions chiefly as a stomach poison, and an attempt is made to reduce its volatility and hence cause it to remain on the fruit and foliage as long as possible.

The simplest example is the use of nicotine dissolved in oil. Since nicotine is an alkaloid, it will react with any acidic substance, and numerous "fixed nicotines" have been prepared with fatty acids, resin, peat, and tannin. A particularly useful material is the combination of nicotine with the colloidal clay bentonite. Commercial preparations are on the market, or a tank-mix spray may be made using 1 pint 40 per cent nicotine sulfate (for example, Black Leaf 40) and 5 pounds of bentonite per 100 gallons of water. Two quarts of a light summer oil and an emulsifying agent may be added if desired.

For combinations of nicotine with various insecticides see formulas under other headings.

Nicotine Dusts.—The old-fashioned tobacco dusts were unsatisfactory because they contained variable amounts of nicotine. To overcome this defect, Ralph E. Smith mixed commercial nicotine solutions with various finely divided solids and thus prepared dusts of known strength. The nature of the solid or carrier is very important, for it determines the ease with which nicotine will be liberated at any given temperature. Alkaline carriers, such as lime, cause more rapid liberation than neutral carriers, such as silica. Much work has already been done on the problem of regulating the rate at which nicotine is liberated. With some insects a high concentration maintained for a very short period is most effective; this calls for "fast" dusts. In other cases a moderate concentration for a longer time is better and "slow" dusts are best. An example of a very "fast" dust is that used to control the nymphal stages of the grape leafhopper. This contains an activator, that is, a very alkaline sub-

stance which liberates the nicotine with great rapidity. The composition of nicotine dusts may be given either in terms of actual nicotine or in terms of the nicotine preparation used. The former method is followed in this circular.

A wide variety of nicotine dusts are made commercially, differing in concentration of nicotine and in carrier. They should be used according to the manufacturer's recommendation.

The strengths commonly used are 1.0 per cent[52] nicotine dust for walnut aphid and cherry or pear slug, 1.50 to 2.0 per cent for most of the aphids and thrips, and a 4 per cent dust for the more resistant aphids (such as the pea aphid) and grape leafhopper. Those which have a wet or slimy covering, like the cherry or pear slug, or have glandular hairs, like the walnut aphid, are easily killed with very weak nicotine preparations. Nearly all of the hairy caterpillars, such as the tent caterpillars, webworms, and thistle butterfly larvae, as well as the velvety cabbage worms, to which the nicotine dust adheres readily, are easily killed with a 4 per cent dust if it is used while the caterpillars are young. Smooth caterpillars, like cutworms, on the other hand, do not readily succumb to any ordinary treatment with the material. Insects which are protected with a waxy or cottony material, such as the woolly apple aphid, the mealy plum louse, and mealybugs, are not susceptible to nicotine dust at all unless completely smothered in it.

A number of combination dusts containing nicotine are produced commercially. Arsenate of lead and sulfur are mixed with nicotine dust at the time of manufacture and give convenient combinations for treating different types of insects or insects and fungus diseases at one application.

In using all dusts containing nicotine, it should be borne in mind that a high temperature favors the evolution of nicotine. The best results are obtained only when the temperature is over 70° F. Very poor control results from dusting in cold weather.

Pyrethrins.—For many years the powdered flowers of the pyrethrum plant have been sold for use against such pests as fleas and bedbugs, and mixed with water have been used against such insects as cankerworms. Within the last few years extracts of the flowers have appeared under various trade names. At first these were not standardized except that a certain weight of dried flowers was used to make a gallon of prepared spray. Since different methods of extraction varied in efficiency, the products were far from uniform. It was then discovered that the principal insecticidal constituents are two complex organic compounds which have been called "pyrethrins." The present practice is to produce pyrethrum concentrates having a guaranteed pyrethrin content. This material is frequently used with oil. A typical formula for use against grape leafhopper (p. 76) is:

FORMULA 18
PYRETHRUM AND OIL

Pyrethrum extract (for example, 2 per cent pyrethrins)	1 to 2 pints[53]
Summer-grade commercial oil emulsion or emulsive oil or tank-mix oil with 4 ounces of blood albumin spreader	2 gallons
Water to make	100 gallons

[52] In terms of actual nicotine. If nicotine sulfate solution containing 40 per cent nicotine (as in Black Leaf 40) is used, multiply these percentage figures by 2½.

[53] Since commercial extracts differ in strength, the manufacturer's directions should be followed with each preparation.

Both the amount of pyrethrum extract and oil may be varied; for example, control of greenhouse thrips is satisfactory with ¼ to ½ pint of pyrethrum extract and ½ to ¾ gallon of light-medium emulsive oil per 100 gallons. The oil may be omitted entirely if the pyrethrum extract is increased to ¾ pint and blood-albumin spreader added.

Commercial oils containing pyrethrin at 0.5 to 1.0 per cent are obtainable for use against various field pests, such as leafhoppers and cucumber beetles.

Dusts of known strength may be prepared by adding pyrethrin concentrate to a carrier such as talc. Alkaline carriers such as lime are usually inadvisable because pyrethrins are not stable in the presence of basic substances.

SELENIUM

A commercial preparation containing selenium in combination with potassium and ammonium sulfides has given good results against several species of mites (for example, the Pacific mite) on grapes. It is sold as a concentrated solution containing 6.4 ounces of selenium per gallon and for use is diluted 1 volume to 600 or 800 volumes of spray water. The addition of 4 to 6 ounces of blood-albumin spreader per 100 gallons of spray improves wetting, and the addition of 2 to 6 pounds of sulfur greatly prolongs the effect.

Soluble selenium compounds have harmful effects upon animals and humans who ingest them, and much attention has been paid by public-health officers to the possible effects of selenium-containing sprays. All indications are that very little selenium is absorbed by grapes and that the amount left at harvest time is too small to have an effect. Application should be made as long before that time as possible. But until an official tolerance for selenium is established by the federal and state authorities, its use cannot be considered to be officially approved.

SOAPS

When animal or plant fats and oils are treated with hot alkali, soaps are formed. These soaps consist of the fatty acids from the fats and oils combined with the sodium or potassium hydroxide of the alkali. Similarly, resin soaps may be formed. By first treating certain petroleum products with strong sulfuric acid under specified conditions and then adding alkali, a number of compounds called "sulfonated petroleum soaps" are prepared. These various soaps all have valuable properties as emulsifying agents and wetting agents, which will be discussed in a later section. By themselves, soaps are sometimes used against soft-bodied insects at the rate of 4 to 10 pounds per 100 gallons of water. Their greatest use, however, is with other insecticides, such as nicotine (formula 16, p. 171) or nicotine and oil sprays. Largely on account of lower cost, fish or whale-oil soaps have been used more than other kinds; but powdered soaps are very convenient, and even laundry soap may be used if it is first dissolved in hot water.

SULFUR

Sulfur is used in four forms: (1) as a dust, (2) as a suspension, (3) as a solution of lime-sulfur or ammonium polysulfide, and (4) as dry lime-sulfur. The dust and the suspension have comparatively little value against most insects but are of great value against fungi and against mites.

Dusting Sulfur.—This is mostly produced either by precipitation by cooling sulfur vapor, or by grinding. Precipitated sulfur usually has less tendency to cake. Caking can be prevented with any type of sulfur by adding a small percentage of dehydrated lime, kaolin, or other inert powder.

The essential feature of any good dusting sulfur is extreme fineness. Recognition of this by manufacturers has led to the use of the names "superfine," "cloud," "microscopic," "smoke," "colloidal," "fog," and similar terms. Practically all brands are now fine enough so that only a very small percentage fails to pass through a 300-mesh screen. Such materials usually adhere well and find extensive use against red spiders and other mites. Combination treatments including sulfur for control of mildew are also widely used.

Sulfur Paste or Wettable Sulfur.—These form suspensions of finely divided sulfur in water. Either precipitated or ground sulfur will serve. An emulsifying agent is needed to make the suspension stable enough for use. Soap, calcium caseinate, glue, flour, or any of a wide variety of commercial preparations may be used. If the emulsifying agent is intimately mixed with the sulfur, the resulting powder is readily wet by water, from which fact the term "wettable sulfur" was derived. When a small percentage only of water is added, a thick paste is produced, which may be diluted further as needed.

Homemade wettable sulfur may be prepared by the following formula:

FORMULA 19
HOMEMADE WETTABLE SULFUR

Calcium caseinate	½ pound
Water	½ gallon
Sulfur (dusting grade)	5 pounds
Water to make	100 gallons

Make a smooth paste of the calcium caseinate and ½ gallon of water, mix with the sulfur, and add enough water to make 100 gallons. The same formula may be used with ¾ ounce of glue dissolved in 1½ gallons of hot water instead of the calcium caseinate paste.

Lime-Sulfur Solution.—This is a reactive solution containing several compounds of lime and sulfur. Those of chief insecticidal value are the polysulfides, which consist of one atom of calcium combined with three to five atoms of sulfur. Such compounds readily take up oxygen, decompose, and deposit extremely finely divided sulfur. Lime-sulfur solution is alkaline and decidedly caustic to most foliage. Its principal use is as a dormant spray for the control of certain fungus diseases, scale insects, red spider, and a variety of other resistant pests of deciduous trees.

Commercial lime-sulfur solution is usually 32° or 33° Baumé. The Baumé scale is a method of expressing the density of liquids. It is being replaced by the use of specific gravity. A 33° Baumé preparation has a specific gravity of 1.295, which means that 1 cubic centimeter weighs 1.295 grams, or 1 gallon weighs 10.8 pounds. Such material needs only to be diluted for use. See table 2 (p. 175).

Commercial lime-sulfur solution has the important advantage that it is standardized at 29 to 30 per cent by weight of calcium polysulfide, which is the valuable ingredient. Hence it can be diluted with assurance. Homemade preparations are nearly always weaker than the commercial product; and

while their value is indicated by the specific gravity, the polysulfide content should be determined by chemical analysis if the finished spray must have a precise concentration of active ingredients.

Lime-sulfur solution may be made at home as follows:

FORMULA 20

HOMEMADE LIME-SULFUR SOLUTION

Quicklime	100 pounds
Sulfur (sublimed or powdered)	200 pounds
Water to make	100 gallons

Heat about one third of the total volume of water required. When the water is hot, add all of the lime, and then immediately all the sulfur, which should previously have been made into a thick paste with water. After the lime is

TABLE 1

DILUTION TABLE FOR CONCENTRATED LIME-SULFUR SOLUTION*

Degrees Baumé	Specific gravity	Amount of concentrated lime-sulfur to make 50 gallons of spray solution		
		Summer or foliage strength	Winter or dormant strength	
			San Jose scale	Blister mite†
		gallons	*gallons*	*gallons*
36	1.330	1¼	5½	4¾
35	1.318	1¼	5¾	5
34	1.306	1½	6	5
33	1.295	1½	6¼	5¼
32	1.283	1½	6½	5½
31	1.272	1½	6¾	5¾
30	1.261	1¾	7	6
29	1.250	1¾	7¼	6¼
28	1.239	1¾	7½	6½
27	1.229	2	8	6¾
26	1.218	2	8½	7¼
25	1.208	2	8¾	7½
24	1.198	2¼	9¼	8
23	1.188	2¼	9¾	8¼
22	1.179	2¼	10¼	8¾
21	1.169	2½	11	9¼
20	1.160	2½	11½	9¾

* From: Diegler, E. H., and A. M. Daniels. Lime-sulphur concentrate. U. S. Dept. Agr. Farmers' Bul. 1285:11. 1922.

† See also "Pear Leaf Blister Mite," page 99.

slaked, another third of the water should be added, preferably hot. The mixture should then be cooked until a clear orange-colored solution is obtained (usually 45 to 60 minutes), when the remainder of the water should be added, either hot or cold, as is most convenient. The boiling due to the slaking of the lime thoroughly mixes the ingredients at the beginning, but stirring is necessary during the subsequent cooking. After the wash has been prepared, it must be allowed to settle and then be strained through a fine sieve as it is being run into the spray tank. The resultant product is a concentrated solution of lime-sulfur, usually 27° to 28° Baumé, which should be diluted about six times with water for a winter spray. The solution may be diluted to any desired concentration by means of a hydrometer for liquids heavier than water and the data in table 1, which gives the dilutions for lime-sulfur solutions in dif-

ferent initial concentrations. (Note that the amounts given in table 1 are for 50 gallons of spray.) The dilution is particularly important where the material is to be used on plants in foliage, which may be easily injured if the spray is too concentrated.

Dilutions of the commercial 32° to 33° Baumé product are often given as the ratio of volume of lime-sulfur concentrate to final volume of spray. Thus if 10 gallons are diluted to 100 gallons, the resulting solution is a 1 to 10 lime-sulfur spray. This method for expressing dilution is usually limited to the use of commercial lime-sulfur of standardized strength.

Lime-sulfur solution is sometimes combined with other materials, as in formula 11 (p. 167), but it is not compatible with several insecticides (see "Compatibility," p. 184). For summer use against mites, wettable sulfur is often added.

Dry Lime-Sulfur.—By evaporation of lime-sulfur concentrate, usually under a vacuum or in presence of an inert gas, a dry powder is obtained. This product is not identical chemically with lime-sulfur in solution, and the addition of water does not exactly reproduce the original material. If the powder soaks for several hours, or better, at an elevated temperature, the resulting liquid more nearly resembles liquid lime-sulfur. Increased efficiency is secured by removing the insoluble residue. On account of this complicated behavior, dry lime-sulfur is seldom used, liquid lime-sulfur or oil being preferred.

Ammonium Polysulfide.—Instead of reacting with lime, sulfur may be caused to react with ammonia to form a yellow solution of ammonium polysulfide. The commercial preparations contain about 41 per cent ammonium polysulfide and are offered for use instead of lime-sulfur solution. Ammonia readily escapes with simultaneous deposit of sulfur, and hence solutions must be kept in tightly closed containers.

TARTAR EMETIC

In recent years an antimony compound, tartar emetic, chemically known as "potassium antimonyl tartrate," has become important for control of gladiolus thrips and citrus thrips. Sugar is used as an attractant. The concentration of poison and bait in the spray for use on citrus depends on the method of application, as shown in the following formulas. Citrus thrips have become resistant to tartar emetic in some districts.

FORMULA 21
TARTAR-EMETIC SPRAY FOR BOOM SPRAYER OR BROOM GUNS

Tartar emetic	1 pound
Sugar	1 pound
Water	100 gallons

For oranges and grapefruit, use 2½ gallons per average-sized tree, applied with a boom sprayer or broom guns. For lemons, double the amounts of tartar emetic and sugar.

FORMULA 22
TARTAR EMETIC SPRAY FOR SPRAY DUSTER

Tartar emetic	7½ pounds
Sugar	7½ pounds
Water	100 gallons

For oranges and grapefruit, use 20 gallons per acre of average-sized trees, applied with a spray-duster (fig. 182). For lemons double the amounts of tartar emetic and sugar.

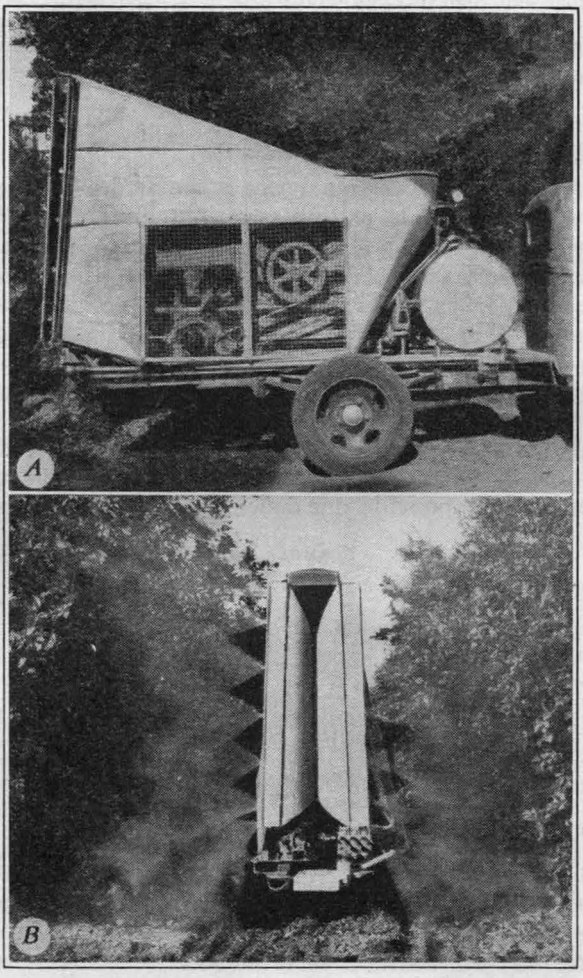


Fig. 182.—*A*, Spray-duster built by the Experiment Station and used for applying tartar emetic for citrus thrips. Note the nozzles in the fishtail outlet of the duster. This machine may apply dust alone, liquid alone, or dust and liquid in combination. *B*, Rear view of same machine, shown applying but 20 gallons of tartar-emetic spray per acre, the spray being well distributed by the blast of air from the fishtails. (From Ext. Cir. 123.)

For other thrips, slightly different formulas have been found advisable as described under the several pests, for example, 12½ pounds of tartar emetic and 25 pounds of sugar for the onion thrips and 2 pounds of each for pear thrips. A special formula of 4 pounds of tartar emetic and 16 pounds of brown sugar per 100 gallons of water is recommended for control of gladiolus thrips.

THIOCYANATES

Organic thiocyanates are highly toxic to many species of insects. The simplest one of practical value is lauryl thiocyanate, but the most widely used one is known chemically as β-butoxy-β′-thiocyanodiethyl ether and is sold as a 50 per cent solution in oil under the trade name Lethane. It may be used as a toxicant in oil sprays, as in fly sprays, or absorbed upon a carrier and applied as a dust.

WHITEWASH

Use has long been made of certain dormant sprays designed to deposit such a thick coating on tree trunks as to prevent hatching of eggs or emergence from eggs or pupal cases. The best material because of its efficiency and cheapness is a suspension of freshly slaked lime. The simplest formula is:

FORMULA 23
WHITEWASH

Water	2 gallons
Quickline	10 pounds

Add more water after slaking, to bring the wash to the desired consistency.

A formula used to control the potato leafhopper on citrus trees and at the same time overcome any possible zinc deficiency in the trees is as follows:

FORMULA 24
LIME AND ZINC WHITEWASH

Hydrated lime (15 pounds for Navel oranges and 30 pounds for Valencias)	15 to 30 pounds
Zinc sulfate	7 pounds
Water	100 gallons

A formula advocated by the United States Department of Agriculture is:

FORMULA 25
GOVERNMENT WHITEWASH

Quicklime	40 pounds
Salt	15 pounds
Rice flour	3 pounds
Spanish whiting	½ pound
Glue	1 pound
Water	5 gallons

BAITS

Two kinds of baits are used in controlling insects: (1) those containing a poison whose function is to kill all individuals that eat or drink the bait, and (2) those used to attract insects to a given place for the purpose of ascertaining the population or catching them in a mechanical trap. Several examples of each have been mentioned in earlier sections. Arsenic is the commonest poison used.

Sodium Arsenite.—Arsenic trioxide may be converted into a very soluble compound, sodium arsenite, by heating with a solution of sodium carbonate (washing soda, sal soda) or sodium hydroxide (lye). Sodium arsenite is ex-

tremely poisonous to plants and animals and acts more rapidly than any other common arsenical compound. It is commonly used in weed killers, poison fly papers, cattle dips for control of ticks, ant sirups, and to some extent in poison baits. It may be purchased as a white powder, but various preparations contain different amounts of arsenic. Hence operators often prefer to make it from arsenic trioxide.

FORMULA 26
SODIUM ARSENITE SOLUTION

	Small quantity	Large quantity
Arsenic trioxide	1 ounce	1 pound
Washing soda	2 ounces	2 pounds
Water	½ pint	1 gallon

Put all the ingredients together in an iron or graniteware kettle (do not use aluminum, because it will be dissolved) of sufficient size to allow for considerable frothing, and boil 15 to 20 minutes or until the solution is clear. This formula contains some excess washing soda, which hastens the solution of the arsenic trioxide and does not impair the product.

Poison Baits.—Most poison baits are made with bran, but occasionally, as in formula 32, with fruit. The poison bran mashes given in formulas 27 and 28 are used for several kinds of insects, including black vine weevil, range cranefly, and grasshoppers.

FORMULA 27
POISON BRAN MASH

	Small quantity	Large quantity
Bran	1 pound	25 pounds
Arsenic trioxid or paris green	2 teaspoons	1 pound
Molasses	2 tablespoons	2 quarts

A solution of formula 26 (⅓ pint for the small quantity or 1 gallon for the larger), or liquid sodium arsenite weed killer, 8-pound strength[54] (2 teaspoons for the small quantity or 1 pint for the larger) may be used in place of the arsenic trioxide.

If arsenic trioxide or paris green is used, mix it dry with the bran and add the molasses after diluting somewhat with water. Mix thoroughly and add enough water to make a moist mash which will broadcast easily. If one of the liquid arsenical solutions is used, it may be mixed with the molasses and bran, and water added as needed. The molasses may be omitted without greatly lessening the effectiveness of the bait. Alfalfa meal, shorts, dried beet pulp, or rice meal may be substituted for bran in any of these formulas. Up to three quarters of the bran may be replaced by well-dried sawdust in this and the following formula:

FORMULA 28
CITRUS BRAN MASH

Bran	25 pounds
Arsenic trioxide	1 pound
Molasses	2 quarts
Lemons (or oranges)	6 fruits
Water (about)	4 gallons

[54] That is, containing 8 pounds sodium arsenite per gallon.

Mix the materials as follows: First stir together thoroughly the arsenic trioxide, molasses, and water. Grind the lemons, including the rinds, in a meat grinder, or chop fine and add. Then slowly pour the combined mixture over the bran and stir thoroughly until an even mixture is secured. Instead of arsenic trioxide, the solution of formula 26 or a liquid sodium arsenite weed killer may be used, the quantities needed being the same as given in the last column of formula 27. The amount of water to use in the preparation of these baits will vary according to the coarseness of the bran, or substitute, used. A barely moist mash is preferable to a wet one because it does not harden under the heat of the sun and remains palatable, while wet mash bakes and becomes unattractive.

A very satisfactory bait for slugs and snails may be made as follows:

FORMULA 29
SLUG AND SNAIL BAIT

	Small quantity	Large quantity
Bran	1 pound	16 pounds
Blackstrap molasses	2 tablespoons	1 pint
Calcium arsenate	1 ounce	1 pound
Metaldehyde	½ ounce	½ pound
Water	1 pint	2 gallons

Mix the dry ingredients together thoroughly, then add the molasses dissolved in the water, and remix. If the metaldehyde cannot be obtained, the bait is fairly satisfactory without it. For use in citrus orchards, both the metaldehyde and molasses may be omitted.

Many very satisfactory commercial snail and slug baits in granular, powder, or pellet form are available. Pellets are easy to scatter, and 1 pound may be used in place of about 4 pounds of the ordinary granular-type baits.

Caution.—All preparations of arsenic are dangerous, particularly those containing it in soluble form. Children and animal pets occasionally consume ant sirups when these are not kept in proper safety containers. See page 154 for antidotes for arsenic.

FORMULA 30
EUROPEAN EARWIG BAIT[55]

Wheat bran	12 pounds
Sodium fluosilicate	1 pound
Fish oil	1 quart

The poisonous ingredient in this bait is sodium fluosilicate.

Fluosilicates are of use in other poison baits in the place of arsenic compounds, as in the three following formulas:

FORMULA 31
ARMYWORM AND CUTWORM BAIT

Bran	50 pounds
Molasses	1 quart
Sodium fluosilicate	2 pounds
Water sufficient to make a slightly moist mash.	

[55] From: Crumb, S. E., P. M. Eide, and A. E. Bonn. The European earwig. U. S. Dept. Agr. Tech. Bul. 766:1–76. 1941.

This formula is especially useful against armyworms.

FORMULA 32
FRUIT BAIT

Cull or low-grade raisins	50 pounds
Bran or shorts	50 pounds
Sodium fluosilicate	5 pounds

The raisins are first soaked 12 hours in water and drained. The bran or shorts and sodium fluosilicate are thoroughly mixed dry. All are then mixed together and run through a meat grinder. This is broadcast over the fields or scattered along the rows or around the bases of the plants.

Dried ground peelings and cores of pears or other fruits might be substituted for raisins. This bait is especially recommended for the control of certain weevils or snout beetles, particularly the strawberry root weevil, the rough strawberry weevil, and the black vine weevil.

Ant Sirup.—Arsenic is also the toxic ingredient of most ant sirups, as in the following one:

FORMULA 33
CALIFORNIA ARGENTINE ANT SIRUP

	Small quantity	Large quantity
Sodium arsenite	26 grains	1 ounce
Benzoate of soda	14½ grains	½ ounce
Honey (any aromatic kind)	1 pint	1 gallon
Water	1 pint	1 gallon

The United States Bureau of Entomology and Plant Quarantine recommends another formula for Argentine ant sirup, which has the advantages of stability in hot weather, freedom from crystallization, and continued attractiveness.

FORMULA 34
BUREAU OF ENTOMOLOGY ARGENTINE ANT SIRUP

Granulated sugar	12 pounds
Water	11 pints
Tartaric acid	¼ ounce
Benzoate of soda	⅓ ounce
Sodium arsenite	¾ ounce
Hot water	½ pint
Honey, strained	2 pounds

Combine granulated sugar, water (11 pints), tartaric acid, and benzoate of soda; boil slowly for 30 minutes; and allow to cool. Dissolve the sodium arsenite in ½ pint of hot water and cool. Add the poison solution to the sirup and stir well; then add the honey and mix thoroughly.

A considerable saving may be made by substituting an equal amount of a low-grade aromatic honey for the sugar in formula 34, and in this case the tartaric acid may be omitted.

Lures.—A good example of nonpoisonous baits, used mainly to attract insects, is offered by the material used in bait pans for estimating the population of adult codling moths. The insects are attracted to the pans or pails containing the bait and some of them fall into the liquid. The number thus caught is a measure of the relative populations, and sprays for the destruction of the eggs and crawling larvae can thus be applied at the most effective times.

FORMULA 35
CODLING-MOTH BAIT

Malt (Diamalt)	1 pint
Compressed yeast	1 cake
Water	19 pints

A bait of different composition is used for determining the proper time to spray with cryolite for the control of the walnut husk fly. The active ingredient is a protein or amino acid.

FORMULA 36
WALNUT-HUSK-FLY BAIT

Casein	7 ounces
or	
Glycine (commercial grade)	3 ounces
Commercial lye	4 ounces
Water	1 gallon

MISCELLANEOUS TOPICS RELATING TO INSECT CONTROL

Bands.—See "Codling Moth" under "Apple and Quince" (p. 13).

Compatibility.—Combination sprays or dusts fall into two classes. In the first class, two or more insecticides are used against the same insect with the idea that those which escape one ingredient will be killed by the other. An example is the use of oil and nicotine sprays against various kinds of aphids. The second class of combination sprays includes those intended for use against two or more pests of different types; these may be different species of insects, different species of fungi, or both insects and fungi. An example is the use of bordeaux mixture with basic lead arsenate for simultaneous control of peach twig borer and brown rot of peaches.

In both classes the question arises as to what materials may be used together. This is much more than merely a matter of whether a reaction occurs between the materials used. Two types of incompatibility may be distinguished: (1) a harmful substance is formed or liberated with consequent injury to plants; and (2) a useful ingredient is removed and the effectiveness lessened. The difference in reaction of plants in dormant and in foliage condition must be considered, for mixtures extremely toxic during the summer may be entirely satisfactory during the winter. A practical factor which lessens the number of useful mixtures is the necessity that the correct times for application of each of the components must coincide at least fairly closely.

Table 2 has been constructed to show the two types of incompatibility, and reasons are given so far as they are definitely known. Additional information regarding the same substances and others not included in the table is given in the sections dealing with specific insecticides. Owing to climatic variations, it is possible to use certain of the incompatible mixtures in certain districts. Before this is done, the advice of the local farm advisor should be obtained. An important summary of both theoretical and practical data on compatibility of insecticides and fungicides is contained in the California State Department of Agriculture Special Publication 184.[56] Everyone using spray

[56] California State Department of Agriculture. Preliminary drafts of compatibility data regarding economic poisons used for plant protection. California State Dept. Agr. Spec. Pub. 184:1–81. 1941.

materials in combination or close sequence should be familiar with this publication.

Emulsification and Deposit of Spray Materials.—Three principal stages may be distinguished in the application of sprays which are used with water: (1) The insecticide, for example lead arsenate or spray oil, and the water are separate. (2) An intimate mixture of finely divided solid or liquid with the water is formed. (3) After spraying, most of the water and some of the insecticide have run off, leaving the remainder on the plant or insect. Two critical points should be noticed—namely, that between 1 and 2, involving the formation of a suspension or emulsion; and that between 2 and 3, having to do with the amount and mode of deposit of the toxic material.

If a liquid and an insoluble, finely ground solid or two immiscible liquids are put together with sufficiently violent agitation, one material will become uniformly distributed within the other, a suspension being formed in the first case and an emulsion in the second. Such preparations, however, are unstable, and separation occurs soon after the agitation ceases. In order that a uniform mixture may be maintained, a third material, possessing certain peculiar properties, must be present. Such materials are called "emulsifying agents." They collect, or are absorbed, at the surface of the solid particles or liquid droplets and prevent them from coming together. Preparations containing an emulsifying agent or emulsifier are said to be "stabilized," though it does not follow that they will remain uniform indefinitely. When an emulsified liquid, for example, oil, separates from an emulsion, the latter is said to "crack," or "break." If the oil does not completely separate but merely rises with the emulsifying agent to form a very concentrated emulsion, it is said to "cream." This is very easy to put back into the original state, but a broken emulsion is often very difficult to restore. The terms "tight" and "loose" are used to designate varying degrees of stability of either emulsions or suspensions.

When a finely divided, suspended solid material clumps, it is said to "flocculate," and substances used to prevent this are often called "deflocculators." Thus some commercial brands of lead arsenate are "deflocculated"—that is, a material is added to the dry powder which will make it easier to keep in suspension in water.

The substances capable of acting as emulsifying agents are extremely numerous. Among those of principal interest with sprays are the soaps (from fatty acids, resins, or petroleum), cresylates, proteins (casein, albumin, gelatine, glue), hydrolyzed starch, flour paste, saponins, and bordeaux mixture.

In the application of sprays to solid surfaces, a number of important points need to be considered. If a mechanical mixture of lead arsenate and water is sprayed upon foliage, it will be observed that the mixture draws back from the surface, forms large drops, and rolls off, with the result that an uneven deposit of insecticide is left there. In other words, proper wetting does not occur. To bring this about, a wetting agent or spreader must be included. Such a substance will collect at the surface of the leaves and enable the water to really wet this surface. By also increasing the viscosity of the spray liquid, it enables a thicker layer to remain upon the foliage after spraying has ceased. The purposes served by the wetting agents and emulsifying agents are obviously entirely different, but the conditions are similar and in general the

TABLE 2

INCOMPATIBILITY CHART

Materials combined	Result	
	Toxic substance formed	Efficiency decreased
1. Standard lead arsenate:		
a. With oil emulsions (soap)	Forms lead soaps and liberates soluble arsenic; also breaks oil emulsion	.....
b. With soaps	Forms lead soaps and liberates soluble arsenic	.....
c. With lime-sulfur or ammonium polysulfide	Forms lead sulfide; liberates soluble arsenic and decomposes polysulfide	.....
2. Calcium arsenate:		
a. With sodium fluosilicate, barium fluosilicate, or sodium fluoaluminate	Forms calcium fluoride and liberates soluble arsenic, unless excess lime is present	.....
b. With soap	.....*	Forms insoluble calcium soaps
3. Bordeaux mixture or copper carbonate:		
a. Followed by any cyanide preparation	Forms complex cyanides toxic to foliage	.....
b. With oil emulsions (soap)	Forms copper soaps and breaks oil emulsion	Forms insoluble copper soaps and reduces efficiency as a fungicide
c. With soaps	.....	
d. With lime-sulfur	.....	Forms insoluble copper sulfide
4. Hydrogen cyanide gas or calcium cyanide:		
a. Preceded by bordeaux mixture or copper carbonate	See 3*a*	.....
b. With nicotine preparations	.....	Cyanide requires acidic condition; nicotine requires basic condition
5. Sodium fluosilicate:		
a. With calcium arsenate	See 2*a*	.....
b. With soaps	Decomposes fluorine compounds and liberates soluble fluoride	.....
c. With lime	Small amount of lime gives rise to soluble fluoride	Large amount of lime forms insoluble calcium fluoride and reduces efficiency
6. Barium fluosilicate:		
a. With calcium arsenate	See 2*a*	.....
b. With nicotine sulfate	Forms barium sulfate and liberates soluble fluoride	.....
c. With soaps	Forms insoluble barium soaps and liberates soluble fluorides	.....
d. With lime	See 5*c*	.....
7. Cryolite (sodium fluoaluminate):		
a. With calcium arsenate	See 2*a*	.....
b. With soaps	Decomposes fluoride compounds and liberates soluble fluoride	.....
c. With lime	See 5*c*	.....

* If pure calcium arsenate were used, soluble arsenic would be liberated, but the excess lime in commercial calcium arsenate usually prevents this reaction.

TABLE 2—(*Concluded*)

Materials combined	Result	
	Toxic substance formed	Efficiency decreased
8. Lime:		
a. With dinitro-*o*-cyclohexyl-phenol	.....	Calcium salt has less effect as contact poison
b. With pyrethrum	.....	Alkali destroys pyrethrins
c. With derris	.....	Alkali destroys rotenone
d. With soaps	.....	Insoluble calcium soaps formed
9. Oil emulsions (soap):†		
a. With standard lead arsenate	See 1*a*	.....
b. With bordeaux mixture or copper carbonate	See 3*b*	See 3*b*
c. With lime-sulfur	Forms calcium soaps and breaks oil emulsion	Forms calcium soaps and decomposes lime-sulfur
10. Pyrethrum:		
a. With soaps	.....	Long contact destroys pyrethrins
11. Nicotine (sulfate):		
a. With hydrogen cyanide gas or calcium cyanide	.....	See 4*b*
b. With barium fluosilicate	See 6*b*	.....
12. Soaps:		
a. With standard lead arsenate	See 1*b*	.....
b. With bordeaux mixture or copper carbonate	.....	See 3*c*
c. With lime-sulfur	.....	Forms calcium soaps and decomposes lime-sulfur
13. Sulfur:		
a. Followed by oil sprays	With rising temperature may lead to foliage and fruit injury	.....
14. Lime-sulfur or ammonium polysulfide:		
a. With standard lead arsenate	See 1*c*	.....
b. With oil emulsions (soap)	See 9*c*‡	See 9*c*‡
c. With soaps	.....	See 12*c*‡
d. With bordeaux mixture	.....	See 3*d*
15. Tartar emetic:		
a. With bordeaux mixture	.....	Avoided by thrips
b. With lime-sulfur or ammonium polysulfide	.....	Forms insoluble antimony sulfide

† This refers to oil sprays emulsified with soap.
‡Ammonium polysulfide may be used in these mixturers.

same materials act in both capacities. Thus the emulsifying agents listed above are also good wetting agents or spreaders.

It is not true that the presence of a wetting and emulsifying agent ensures the deposit of more insecticide. This is particularly the case with oils, for the coating of emulsifying agent around the oil droplets and wetting agent on the foliage prevent intimate contact of oil with leaf and may actually decrease the deposit. This is in agreement with the observation that a loose oil emulsion is more toxic than a very tight emulsion. Experiments have also shown that a

mechanically maintained emulsion of oil and water without any emulsifier or wetting agent present is most efficient in control of scale insects from the standpoint of concentration of oil needed. But it is lowest in safety, for each time a region is passed over, additional oil is deposited, with the result that in making sure that all parts of a tree are reached, excessive amounts of oil are left on some parts. By including an emulsifier and wetting agent, this continuous "build-up" is avoided and safety insured. With either oils or other materials, an even "film" coating is much easier to obtain when a wetting agent is used.

Since many leaf surfaces are waxy, mineral oils, which readily wet such a surface, are often used as wetting agents with bordeaux mixture, lead arsenate, and other such sprays. Fish oils are sometimes used for the same purpose. Since oils, particularly if of high boiling point, stay on the surface a long time and hold the solid insecticide, they are called "stickers." The term "fixator" is also used sometimes in describing materials that increase the tendency of spray materials to adhere.

Hard and Saline Waters.—Water containing considerable quantities of calcium or magnesium compounds in solution is called "hard" water. If these elements are lacking but soluble compounds of sodium or potassium are present, it is called "saline." The principal compounds present in hard water are calcium and magnesium sulfates, chlorides, and bicarbonates; and those in saline waters are sodium and potassium sulfates, chlorides, carbonates, and bicarbonates. Combined hard and saline water occasionally occurs also. All such types of water give rise to difficulties with certain spray solutions.

Owing to the formation of insoluble lead compounds and the release of soluble arsenic, burning often results from the use of standard lead arsenate in such waters. Basic lead arsenate may usually be substituted. Sodium fluosilicate and cryolite (sodium fluoaluminate) in hard waters give rise to soluble fluoride with consequent danger to plants. Nicotine sprays, activated with soap (for example, formula 16, p. 171), are lessened in efficiency in hard water because the soap is removed as insoluble calcium or magnesium soaps, which are not alkaline enough to liberate nicotine. Similarly soap solutions alone are rendered useless and there is danger of plugging up the spray nozzle. Oil emulsions stabilized with soap become unstable in hard or very saline waters and may break.

Hard water may be softened by the use of washing soda, lye, or soap, or by passage through a commercial water-softening chamber. If washing soda or lye is used, the amount necessary must be ascertained by analysis of the water, for an excess will be as bad as the original water. Many commercial "water conditioners" usually adapted for use with particular insecticides are now available.

Much effort has been expended to find emulsifiers and spreading agents which are not affected by the quality of the spray water. Oil emulsions containing blood albumin or petroleum soaps are relatively unaffected. Insecticides made up with an excess of lime (as are bordeaux mixture, many commercial fluorine preparations, and lime-sulfur) may be used with almost any water. Lastly it should be mentioned that the use of dusts instead of sprays avoids the difficulty.

Heat as an Insecticide and Disinfectant.—A temperature of 130° F, as far as records go, if prolonged for several hours will kill all forms of insect life. This temperature can readily be obtained in well-built buildings which are connected with a steam plant. The first expense of installing radiators is considerably more than that of fumigation with chemicals, but after-treatments are very much cheaper and without danger to the operators or to the contents of the building.

Higher temperatures of 145° to 180° F have been reported as successful in a much shorter period of time than the first figure mentioned. As the desired degree of heat, however, must be obtained throughout the entire mass which is being treated, it is not sufficient to heat the room alone to 145° F or more.

Hot water is also a useful agent for destroying many fungi and other injurious organisms. See "Nematodes, or Eelworms" (p. 136), "Bulb Mite" (p. 32), and "Soil Disinfection."

Soil Disinfection.—For the prevention of soil-inhabiting insects, nematodes, and centipedes, treatment may be practical in seedbeds, or in greenhouse soil, or where limited amounts of material are to be dealt with. Plants are at first slightly retarded, but soon grow with increased vigor in properly disinfected soils.

Steam Cooking.—This is generally considered the most effective method of soil treatment for the above purposes, and various devices have been employed for doing the work. A system of 1½-inch pipes may be laid 18 inches apart and 1 foot below the surface. These pipes should be perforated on their lower sides with ¼-inch holes at intervals of 6 inches and should be supplied with steam at a pressure of 80 to 150 pounds. The soil should be covered with blankets before the steam is admitted, and potatoes buried in different places in the soil. After treatment for an hour, the potatoes may be examined; if they are cooked, the treatment may be considered effective. The soil may be used in place or may be removed to clean benches or beds, using care not to contaminate it again. Benches, frames, and similar equipment should be drenched with boiling water or formaldehyde solution before use.

The inverted-pan method consists in admitting steam below an inverted galvanized-iron pan, furnished with handles for moving, which is pressed down to confine the steam. A size 6 feet wide, 8 feet long, and 6 inches deep has been recommended.

Injurious insects, fungi, nematodes, and weed seeds are destroyed by steam cooking. It has been reported in some cases that the cost has not been greater than that of weeding untreated soil.

Surface Firing.—Brush is frequently piled on seedbeds prepared for sowing and burned. Seed is sown as soon as possible with a minimum stirring of the surface. The effect in this case is very superficial.

Formaldehyde Treatment.—Formaldehyde may be used on seedbeds prepared to sow. The soil may be soaked with a solution of 1 pound of formalin in 6 gallons of water. The soil should be kept covered for a day and allowed to stand for a week before sowing.

Hot-Water Treatment.—Considerable benefit may be derived from drenching the soil with boiling water. Empty pots, flats, pots with soil, and implements may be immersed in boiling water for 5 minutes.

Spray Residue.—On plant products intended for human or animal consumption, the amount of certain insecticides remaining at harvest time is important. Laws have been passed and enforced regarding several of these materials on food for human use. Definite limits are set for arsenic, lead, and fluorine. These limits or "tolerances" (as of 1942–1943) are 0.02 grain of arsenic as arsenious oxide per pound, 0.025 grain of lead per pound, and 0.02 grain of fluorine per pound. Two courses are open to avoid condemnation of produce on account of residue. It may be washed or otherwise cleaned before selling, or the use of these insecticides may be avoided for as long an interval before harvesting as possible. The latter is by far the cheaper method and should be used whenever possible. Thus in most states lead arsenate is recommended for codling-moth control only in the early spray applications, oil and nicotine or other fixed-nicotine sprays being used later in the season.

Even the avoidance of lead-arsenate spray for several weeks before harvest does not ensure a low enough residue on fruit in districts where heavy early applications are needed, and wiping or washing is therefore necessary. For large quantities of fruit, the use of commercial machines is the only way that is practical. A washing fluid containing 1 per cent commercial hydrochloric acid is perhaps most widely used. At 70° F this will bring fruit below the tolerances unless excessive wax has formed or oil sprays have held much lead arsenate on the fruit, when higher temperatures or an alkaline wash is necessary. Most alkaline washes, however, although they remove arsenic efficiently, leave much of the lead; and they impair the keeping quality of fruit.

Sticky Bands.—Several commercial adhesive or sticky products are available for use either directly on tree trunks or on paper or burlap strips which can then be fastened around the trunks. In general they are more satisfactory than homemade banding material. A great number of formulas have been proposed for making such adhesive materials, mostly based on the use of resin and an oil. One of the simplest is three parts resin and one part cottonseed oil, heated together to the boiling point and applied either hot or cold. The most widely used materials are called "Tanglefoot" and "Deadline."

Precautions in Handling Poisons.[57]—Extreme care should be used in handling poisons so that they will not be mistaken for flour, or for food for livestock, or [left] where children or pets can be injured by coming in contact with them. When using materials which are known to be lethal to bees, livestock or other property, one should exercise every precaution to protect all property from damage and, as a means thereto, use only such methods of application and under such climatic conditions at the time of application as shall confine the material to the premises of intended application so as not to cause appreciable loss to bees, livestock or other property on adjacent premises. As a further precaution, it would be desirable when applying materials which might drift onto the property of others in quantities that might be destructive to bees, animals or other property, to notify your neighbors or interested parties sufficiently in advance of the time of application as to safeguard your interests as well as theirs. One should also consider legal restrictions as to the tolerance of various poisons on fruits or vegetables before applying toxic substances.

[57] This section is quoted from a mimeographed release issued by the California State Department of Agriculture.

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